http://astropedia.free.fr

User manual

PreviSat

Satellite tracking for everyone

I. Overview

PreviSat is free open source software to track artificial satellites on a world map. It is developed in C++/Qt and available on Windows, GNU/Linux and Mac OSX operating systems. Its simple and intuitive interface is designed to meet both the needs of the neophyte to those of the casual observer. PreviSat allows to know the position of the satellites in several coordinate systems (cartesian, equatorial, horizontal). To do this, it uses the SGP4 orbital model - revised in 2006 by David Vallado - and orbital elements called TLE provided by Celestrak or the Space-Track. It also displays the position of the Sun and the Moon.

SGP4 model takes into account only the principal natural disturbances acting on the satellite (first terms of the Earth potential irregularities, simplified model of atmospheric drag, lunisolar disturbances or resonance phenomena), it is necessary to regularly reactualize the orbital elements of the satellites in order to guarantee an optimal precision on the position and the speed of the satellites, in particular when there is an orbital correction manoeuvre. The orbital elements placed at the disposal on the site www.celestrak.com (and also on the site www.space-track.org) in the form of text files are presented in the following way :

```
ISS (ZARYA)
1 25544U 98067A   08289.55379628  .00014092  00000-0  10869-3 0  4451
2 25544 051.6421 119.2525 0003675 219.8593 192.3484 15.72261275567472
```

PreviSat has 2 operating modes : real-time mode and manual mode. The first mode allows to monitor in real time the evolution of the position of the satellites. The second mode allows the satellites for dates other than the system date.

Osculating Elements tab contains instantaneous orbital parameters of the orbit of the selected satellite. This allows in particular to estimate the size and shape of the satellite orbit. Satellite Information tab details the various components of TLE and also provides information on the satellite itself (dimensions, maximum magnitude ...).

PreviSat calculates the satellite pass predictions for a given place of observation, with the possibility of setting many parameters (selection of the place of observation, minimum height of the satellite, height of the Sun ...). PreviSat is able to determine quickly and accurately flares produced by the Iridium satellites, which can reach a magnitude of -8.3, which is 30 - 40 times brighter than Venus.

Many display options to customize the GUI are available (zone of visibility of satellites, ground track, Sun, shadow of the Earth, Moon ...). The graphical interface allows easy management of places of observation. A special category of places of observation, called "My Favorites" allows you to group most used observation sites. Two management utilities of TLE are available in the software (TLE updating or creating a TLE file from an existing file).

There are also two features making prediction calculations :

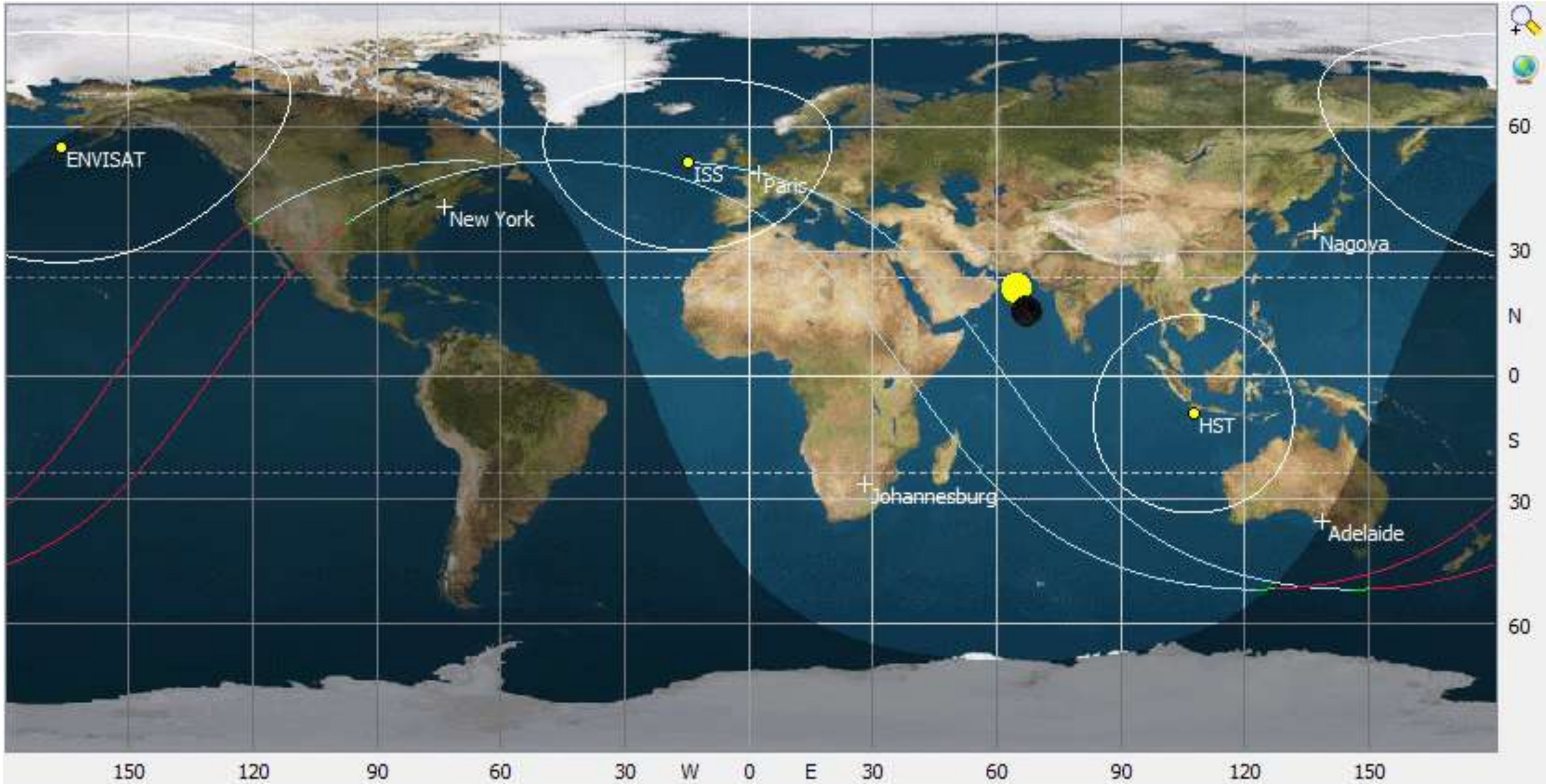
- Calculation of orbital events determines the dates of shadow/penumbra/light transitions, apogee/perigee, transits to nodes of the orbit, etc.
- Calculation of the ISS transits to the Moon or the Sun.

PreviSat has a display "Wall Command Center" resembling as closely as possible to the ISS command control center of NASA. This visualization allows particular view live streaming video of the ISS.

II. Graphical interface

1. World map

When displayed, the **world map** is the main visual element of the graphic interface.



On this, many elements appear of which most important are the places of location, represented by a white cross, and the satellites, represented by a small coloured disc. Labels are assigned respectively with these two elements. The color of the disc representing the satellite varies according the illumination of the satellite :

- the disc is yellow if the satellite is illuminated by the Sun,
- the disc is green if the satellite is in the penumbra of the Earth
- the disc is red if the satellite is in the shadow of the Earth.

The white contour around the satellite represents the **foot print**, so the satellite is visible of the assembly of points of the globle located at the interior of this zone. In reality, the shape of the foot print is always a circle (abstraction made from the flatness of the terrestrial globe), but the projection on the planisphere can produce various forms.

We also draw the **ground track** of the future orbits of the default satellite. The color of this curve is clear blue when the satellite is illuminated by the Sun, green when the satellite is in the shadow of the Earth, and red when the satellite is in the shadow of the Earth.

The **Sun** is drawn by a yellow disc on the maps. For a place of observation whose geographical coordinates merge with the center of the disc representing the Sun, this latter is found at the zenith of the considered place of location.

The **zone of shade** is the area of the globe located during the night. One can observe the evolution of the zone of shade during the day (day/night alternation) and of its shape during the year (seasons).

The **Moon** is also displayed on the maps, and its phase is drawn as it appears in the sky of the observer.

It is important to note that the size of the elements (Sun, Moon or satellites) is not representative of the reality.

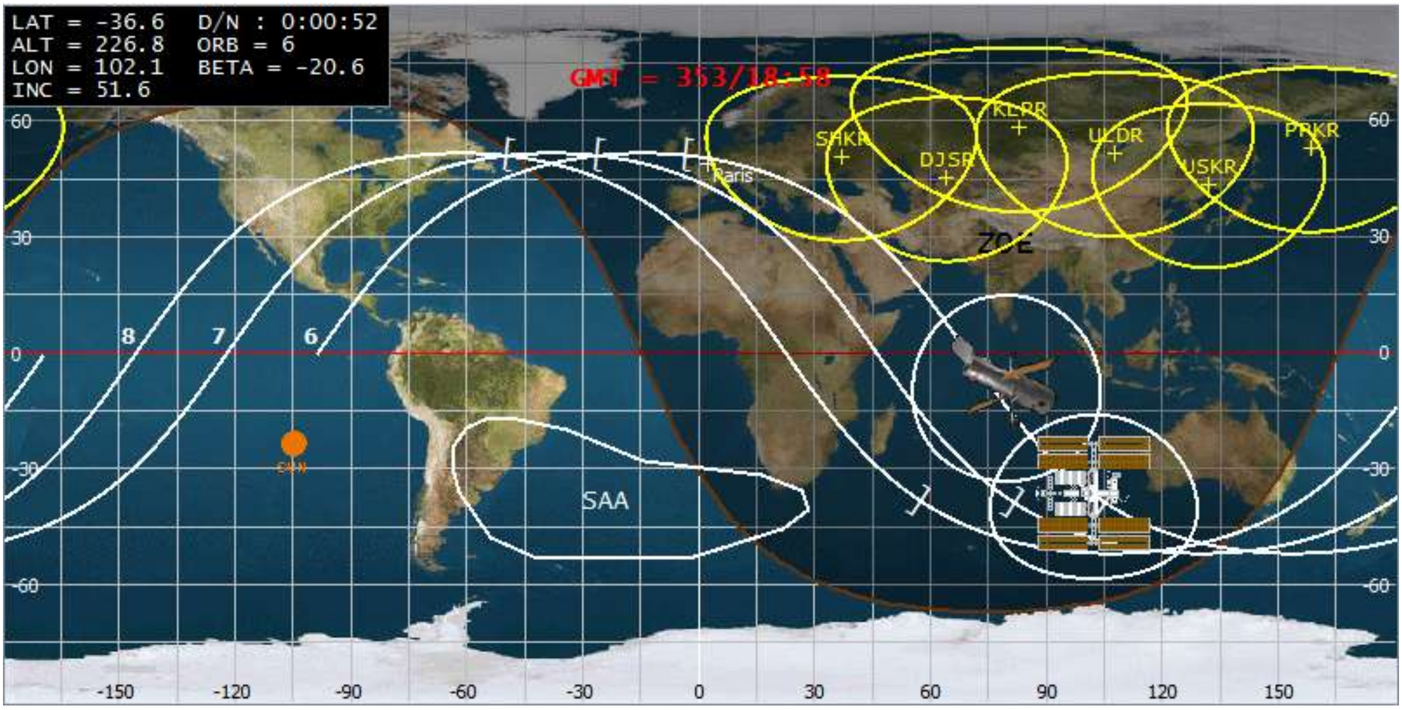
Also displayed on the world ma pis the grid of the geographical coordinates graduated in steps of 30 degrees, and also the tropics. The meridian at the center of the world map is the meridian line of Greenwich.

All elements described above (except the default place of location) can be made nondisplayable by de-selecting the boxes of the Options/Display tab.

It is possible to select the default satelliteby clicking on his disc on the maps or on the radar, or by right clicking on the list of satellites.

2. "Wall Command Center" visualization

When the "ISS Live" box is checked, the representation of the world map is changed.



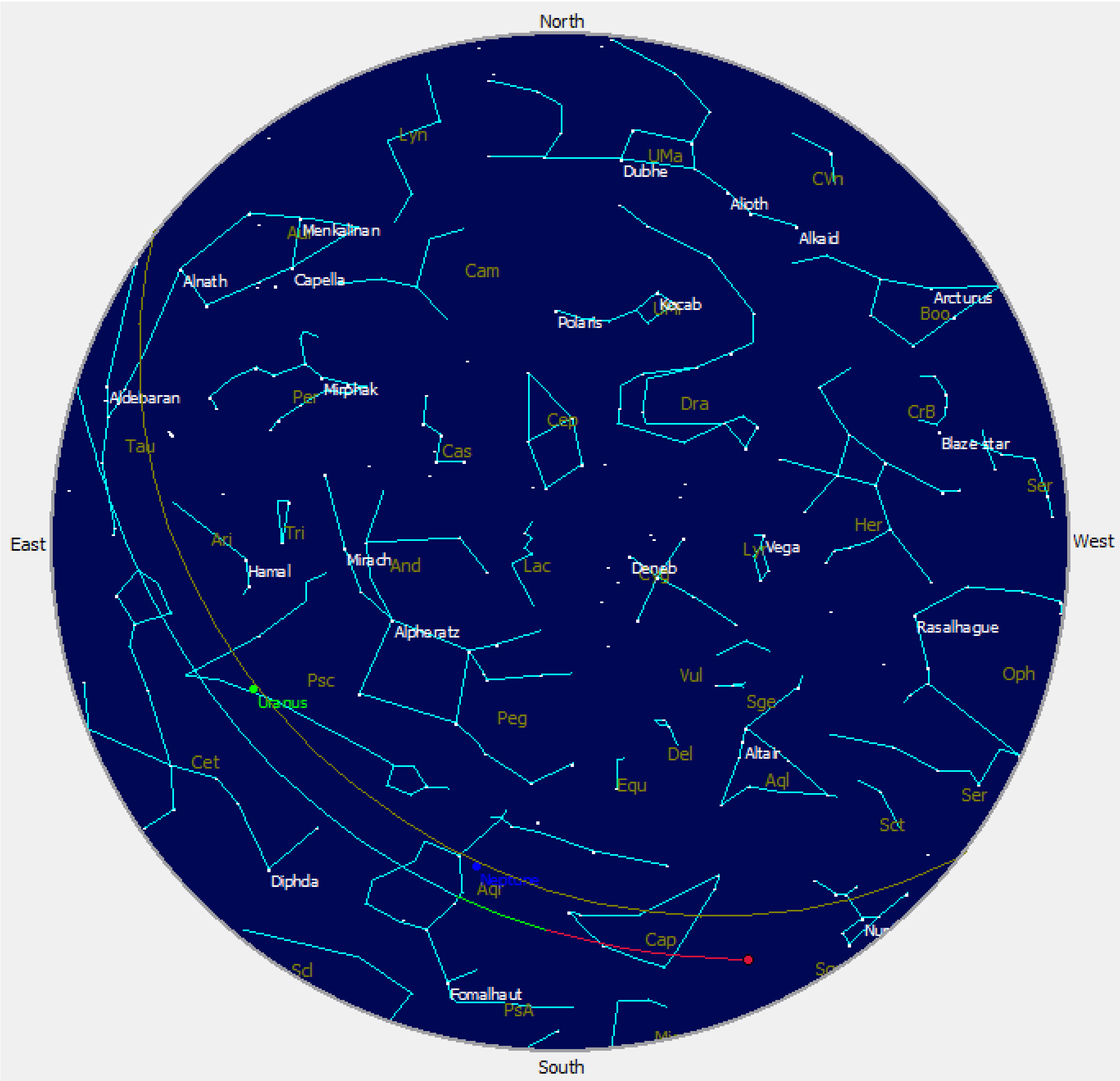
It is then possible to view the live video stream of the ISS by clicking on the "NASA" button. Most of the time, the camera on board the ISS is pointing towards the ground. Sometimes it shows inside of the station, and you may see the crew. During a spacewalk (EVA), the camera is placed on the helmet of an astronaut.

You can double-click on the video in order to display it in fullscreen, or click on the button to have it in a separate window.

Note : because there is some delay in the broadcast of Live ISS stream, times of eclipses observed on the video are not simultaneous with values displayed by PreviSat.

3. Sky map

The **sky map** represents the sky seen the place of observation selected at the given instant.



On this image taken the July 19th, 2015, we can see the satellite ISS near the South-West horizon and it will across the sky. Along the ecliptic (in yellow), we can see Neptun in the Water Bearer constellation (Aqr) and Uranus in the Fishes constellation (Psc).

4. Mode of use : Real time / Manual mode

By default and with each starting, PreviSat is in the Real-time mode, that is to say that the display of the elements of the maps, as well as the numeric data of the Main and Osculating elements tabs, follow the system hour. Various time steps ranging between 1 and 60 seconds can be selected in the drop-down list for the update of the curves on the maps and the data on the tabs.

The **Manual mode** can be activated by several different manners :

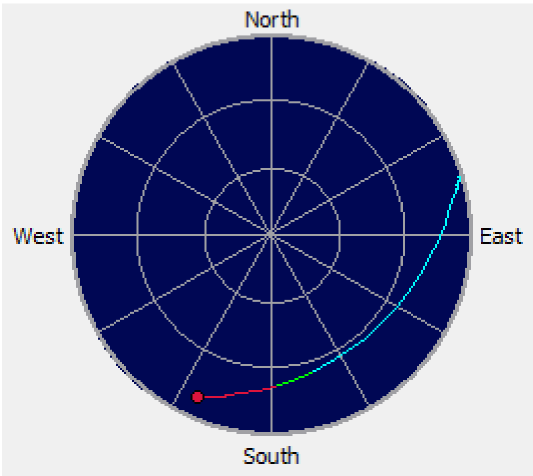
- By selecting the manual mode in the choice list,
- By pressing the keys :
  - F10 : jump between Real-time and Manual mode and vice versa.
  - F11 : move back in time by time step specified in the drop-down list.
  - F12 : move up in time by time step specified in the drop-down list.
- By double-clicking the date in the **Main** or **Osculating elements** tab.

One can also use the manual mode by modifying the value(s) of the date of the Main tab or the **Osculating elements** tab (month, day, year, hour, minutes or seconds).

When the manual mode is activated, a toolbar appears on the **Main** tab making it possible to move automatically during time, from any date.

5. Radar

The radar represents the sky of the observer projected on a plan.



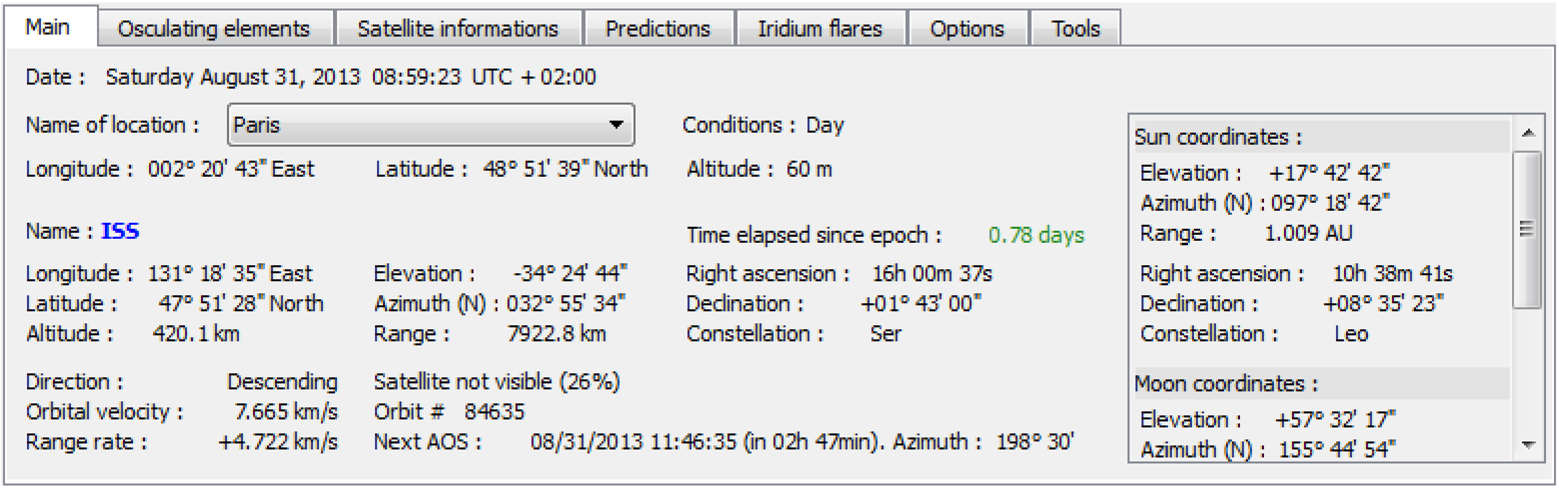
The external circle reproduces the (ideal) horizon of the observer and the center of the radar is the zenith of the place. The other concentric circles are the circles of a height of 30 and 60 degrees. The azimuths are graduated by steps of 30 degrees. It is drawn on the radar, when they are in the sky of the observer, the Sun, the Moon and the selected satellites. The color of the radar is purely indicative and should not represent exactly the color of the sky.

6. Key shortcuts

Key	Shortcuts
F1	Displays the help file.
F8	Screenshot of main window.
F9	Toggle world map / sky map.
F10	Toggle Real-time / Manual mode.
F11 (F6 on MacOS)	Previous step.
F12 (F7 on MacOS)	Next step.
Ctrl + M	Maximization / Minimization of the map.
Ctrl + N	Night vision.
Ctrl + O	Open a TLE file.
Ctrl + S	Save the tab data in a text file.
A… Z	Allows to move in the list of satellites when this one is active.

III. "Main" tab

The **Main** tab contains all necessary information to know the position of the satellite with regards to the place of observation.



First of all, the current date is indicated, which can be that of the system or that chosen by the user. It is possible to pass from the Real-time mode to the Manual mode by double-clicking on the label containing the date. We then point out the coordinates of the default place of observation (name, longitude, latitude, altitude). We also give the **conditions of observation**, that is an indication about the Sun's elevation :

- Day ($H_S > 0°$),
- Civil twilight ($-6° < H_S < 0°$),
- Nautical twilight ($-12° < H_S < -6°$),
- Astronomical twilight ($-18° < H_S < -12°$),
- Night ($H_S < -18°$).

We then give the name of the default satellite, as well as the time elapsed since the epoch of the TLE. The color assigned to the age of the TLE give an approximative indication about its accuracy (the green color indicates a recent TLE, instead of the red color indicates an old TLE).

Then, we grouped the coordinates of the satellite in various reference frames :

- **Longitude, latitude and altitude :**
  They are the terrestrial coordinates over flown by the satellite, where the altitude is calculated compared to the sea level by taking into account the flatness of the terrestrial globe. Longitude and latitude over flown are thus the point of the globe where the satellite passes to the zenith.

- **Elevation, azimuth and range :**
  They are undoubtly the most useful coordinates for the observation, since they are related to the place of observation. The elevation, also called site angle, is the angle counted vertically between the horizon and the satellite. This angle is between 0 and 90° when the satellite is above the horizon, and negative when it is below the horizon[1]. The azimuth is the angle counted horizontally from North and increasing towards the East. This angle, ranging between 0 and 360°, is that which one finds on compasses (North = 0°, East = 90°, South = 180°, West = 270°). Finally, we put the range between the satellite and the place of

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[1] The elevation, when it is positive, is corrected by the atmospheric refraction by the formula given in the **Astronomical Algorithms** 2nd edition, by Jean Meeus, p. 106.

observation (taking into account of the flatness of the Earth).

- **Right ascension, declination and constellation** :
  These coordinates are used to locate the satellite among stars. The right ascension, of which the origin is the vernal point located in the constellation of Fishes, is counted by convention from 0 to 24h and increasing towards the east along the celestial equator. The declination is the angle measured indegrees from one side of the celestial equator to the other (from 0 to +90° in the boreal celestial hemisphere, and from 0 to -90° in the southern celestial hemisphere).

- Given next is various information concerning the motion of the satellite, that is to say the **direction** of the satellite on its orbit (ascending as it moves from South to North, and descending in the contrary case), the **orbital velocity** and the **range rate** (negative if the satellite is approaching the observer).

- One provides, when the satellite has a positive elevation and is not eclipsed, the **magnitude** and the **illumination** (in %). The magnitude value is followed by an asterisk when the satellite is in the penumbra of the Earth, which supposes a weakening of the glare of the satellite.

The **number of orbits** carried out since the launch is displayed (number increased each time the satellite passes to the ascending node).

Finally, we show the **next AOS** date (Acquisition of signal), that is to say the next date when the selected satellite will be above the horizon of the location. The next **LOS** (Loss of signal) is the time when the satellite passes below the horizon. We also give the delay of the AOS (resp. LOS) relative to the current date, and the azimuth where the satellite will appear (resp. disappear).

We then give the coordinates of the Sun and the Moon[2] in the following reference frames :

- Elevation, azimuth, range,
- Right ascension, declination, constellation.

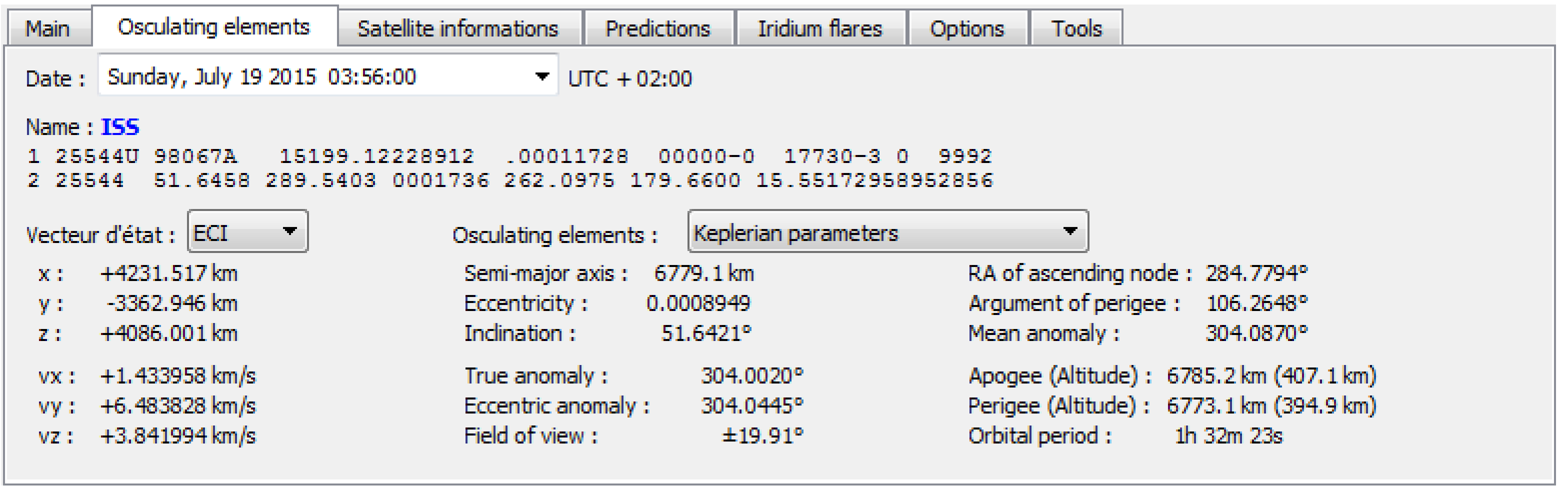
The range given here is the range to the observer, which is generally different from geocentric range. We also give the informations about the Moon phase, its illuminated fraction (in %) and its magnitude.

It is possible to record in a text file the values provided in ths tab by clicking on the **Save** item in the main menu or with the shortcut Ctrl + S.

[2] The Sun and Moon positions are calculated from simplified models (**Astronomical Algorithms** 2nd edition, by Jean Meeus), there can thus be differences compared to precise ephemeris (about thirty arcseconds for the Sun).

IV. "Osculating elements" tab

The **Osculating elements** tab contains the data concerning the position and the velocity of the satellite.



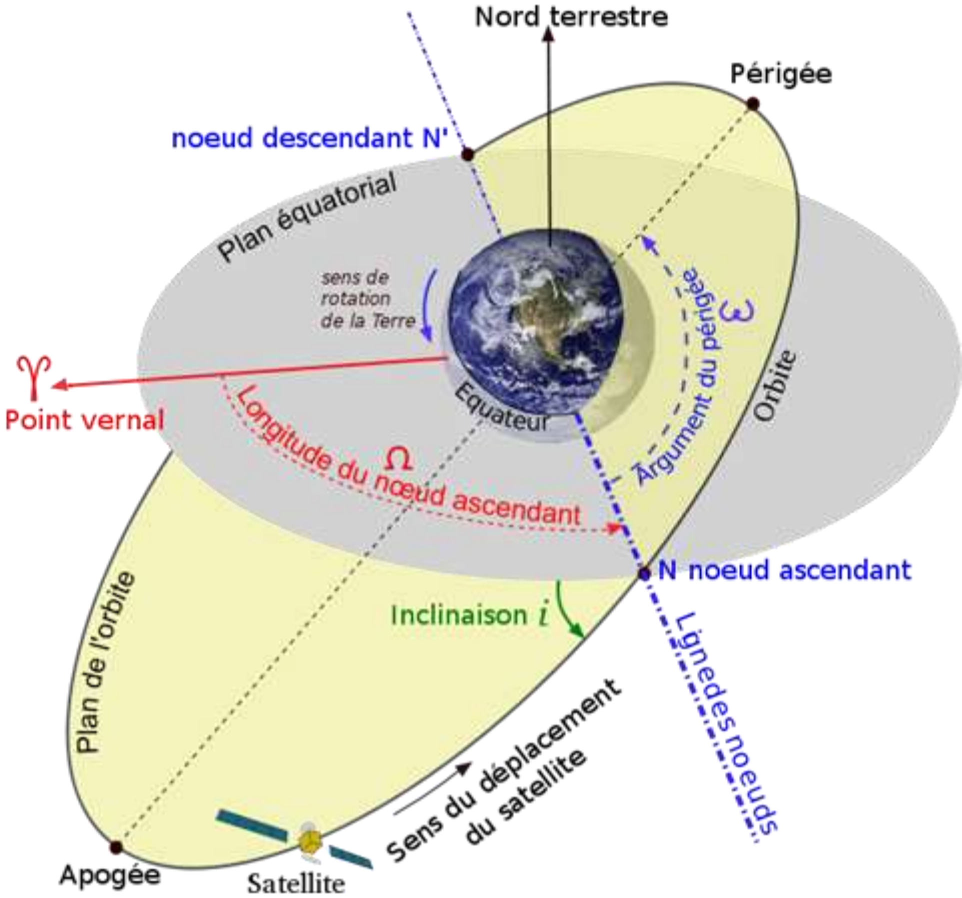
In this tab, we recall the date, which is identical to that of the Main tab, then the name of the satellite and the 2 lines of the orbital elements of the TLE. These orbital elements are known average, that is to say they do not represent the real orbite at the instant of epoch. The osculating elements, true characteristics of the orbit at a given moment, vary with time and represent the orbit that the satellite would follow if all the disturbances which the satellite undergoes disappeared suddenly.

We give first of all under the name of **state vector** the results provided by the SGP4 model, namely the components of the positionvector and the velocity vector. Then starting from thes components, we calculate the following osculating elements[3] :

- The **semi-major axis (a)** of the ellipse, characterizing the size of the orbit,
- The **eccentricity (e)**, characterizing the shape of the ellipse,
- The **inclination (i)** of the orbit measured from the celestial equator, always ranging between 0 and 180°. The types of orbit according to the value of the inclination are the following :
  - The equatorial orbits have an inclination of 0° or 180°,
  - The direct orbits have an inclination ranging between 0 and 90°,
  - The retrograde orbits have an inclination ranging between 90° and 180°,
  - The polar orbits have an inclination of 90°.
- The **right ascension of ascending node (Ω)** is the angle measured between the vernal point and the ascending node of the orbit (point where the satellite crosses the celestial equator plane from the South to the North) and counted along the celestial equator.
- The **argument of perigee (ω)** is the angle counted along the orbital plane between the ascending node and the perigee (point where the radius vector passes to a minimum).
- The **mean anomaly (M)** is the angle counted from the perigee to the mean position of the satellite, considering a mean circular orbit.
- The **true anomaly (ν)** is the angle counted from the perigee to the true position of the satellite.

[3] The formulas used here are from **Fundamental of Astrodynamics and Applications**, 2nd edition, by David Vallado.

One deduces from the preceding osculating elements, the perigee (minimum of the radius vector), the **apogee** (maximum of the radius vector), the **orbital period** as well as the **field of view**.



Other orbital elements are available for circular and/or equatorial orbits. For a circular orbit, we define the following elements :

$$a$$
$$e_x = e\cos\omega$$
$$e_y = e\sin\omega$$
$$i$$
$$\Omega$$
$$\alpha = \omega + M$$

α is named position on orbit.

For an equatorial orbit, we define :

$$a$$
$$e$$
$$i_x = \tan\left(\frac{i}{2}\right)\cos \Omega$$
$$i_y = \tan\left(\frac{i}{2}\right)\sin \Omega$$
$$\tilde{\omega} = \omega + \Omega$$
$$M$$

$\tilde{\omega}$ is named longitude of perigee.

For a circular equatorial orbit, we define :

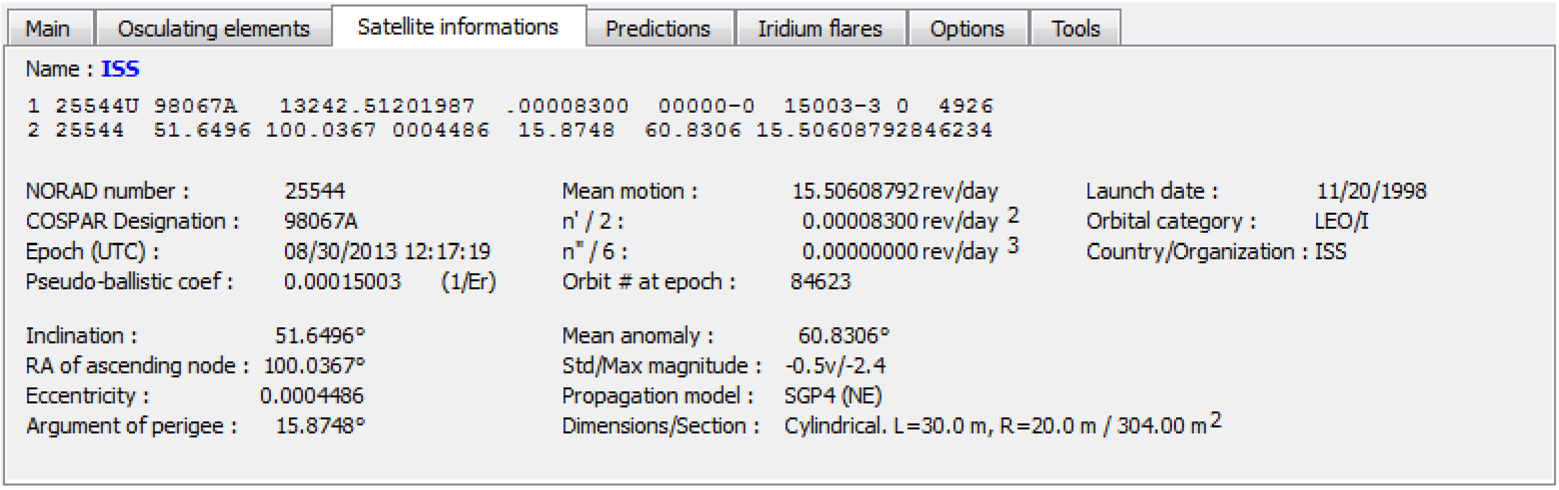
$$a$$
$$e_x = e\cos(\omega + \Omega)$$
$$e_y = e\sin(\omega + \Omega)$$
$$i_x = \tan\left(\frac{i}{2}\right)\cos \Omega$$
$$i_y = \tan\left(\frac{i}{2}\right)\sin \Omega$$
$$l = \omega + \Omega + \nu$$

l is named true longitude argument.

It is possible to record in a text file the values provided in ths tab by clicking on the **Save** item in the main menu or with the shortcut Ctrl + S.

V. "Satellite informations" tab

The **Satellite informations** tab provides the mean orbital elements of the TLE.



We point out first of all the name of the satellite and the élines composing the TLE. We give successively :

- The **NORAD number** : identification number assigned sequentially by North American Aerospace Defense Command. Each NORAD number refers to a single object (satellite, debris).
- The **COSPAR Designation** (COmmittee on SPAce Research) : provides the year of launching, the number of the launch in the year, as well as one to three letters indicating a piece of the launch.
- The **epoch** of the TLE is given peculiar format : the 2 first digits refers to the year, the following digits are the number of days (with decimals) elapsed since January 1st. The epoch is given in Universal Time Coordinated (UTC).
- The **pseudo-ballistic coefficient** caracterizes the atmospheric drag and its dimensionis given in reverse of the Earth radius. SGP4 model uses this value to estimate the atmospheric drag.
- The **mean motion**, expressed in number of revolutions per day.
- The **first time derivative of mean motion divided by 2**, expressed in revolutions per day squared, represents the acceleration or the deceleration of the satellite.It's generally a question of acceleration, when the satellite descends to a slightly lower orbit; a deceleration can occur at the moment of a satellite manoeuvre (this parameter is not used in SGP4).
- The **second time derivative of mean motion divided by 6** is expressed in revolutions per day cubed (this parameter is not used in SGP4).
- The **revolution number at epoch** (from the TLE).
- The mean **inclination.**
- The **right ascension of the ascending node**.
- The mean **eccentricity**.
- The mean **argument of perigee**.

- The "mean" **mean anomaly**.

- The **standard magnitude** and the **maximum magnitude**. The standard magnitude is issued from an internal file in PreviSat. The letter which follows its value indicates how this latter has been determinate; **d** it is calculated according to dimensions of the satellite; **v** it is estimated according to visual observations. The maximal magnitude is evaluated starting from the standard magnitude and semi-major axis and eccentricity.

- The **propagation model** used (SGP4). For the satellites whose orbital period is inferior to 225 minutes, we precise "NE" (Near earth); on the contrary, we indicate "DS" (Deep Space).

- The **dimensions of the object** and the **radar cross section** issued from an internal file.

- The **launch date**.

- The **orbital category** (cf. table 1 below).

- The **country** or **organization** (cf. table 2 below).

It is possible to record in a text file the values provided in ths tab by clicking on the **Save** item in the main menu or with the shortcut Ctrl + S.

Désignation	Signification	Période h	Inclinaison °	Excentricité	Périgée km	Apogée km
ATM	Atmospheric	-	0.0 - 180.0	0.0 - 1.0	<80	0 - 80
TAO	Trans-atmospheric	-	0.0 - 180.0	0.0 - 1.0	0-80	>80
SO	Suborbital	-	0.0 - 180.0	0.0 - 1.0	<0	>80
LEO/E	Equatorial low orbit	1:26 - 2:00	0.0 - 20.0	0.0 - 0.21	80 - 1682	80 - 3284
LEO/I	Intermediate	1:26 - 2:00	20.0 - 85.0	0.0 - 0.21	80 - 1682	80 - 3284
LEO/P	Polar	1:26 - 2:00	85.0 - 95.0	0.0 - 0.21	80 - 1682	80 - 3284
LEO/S	Sun-synchroneous	1:26 - 2:00	95.0 - 104.0	0.0 - 0.21	80 - 1682	80 - 3284
LEO/R	Retrograde	1:26 - 2:00	104.0 - 180.0	0.0 - 0.21	80 - 1682	80 - 3284
MEO	Medium	2:00 - 23:00	0.0 - 180.0	0.0 - 0.5	80 - 34680	1682 - 55209
HEO	Highly elliptique	4:03 - 23:00	0.0 - 180.0	0.5 - 0.92	80 - 14331	13000 - 69280
HEO/M	Molniya	11:30 - 12:30	62.0 - 64.0	0.5 - 0.77	80 - 7294	19489 - 41854
GTO	GEO Transfer	10:00 - 12:30	0.0 - 85.0	0.5 - 0.77	-	-
GEO/S	Stationary geosynchr.	23:55.5 - 23:56.5	0.0 - 2.0	0.0 - 0.01	35353 - 35795	35775 - 36217
GEO/I	Inclined GEO	23:55.5 - 23:56.5	0.0 - 20.0	0.0 - 0.05	33667 - 35795	35775 - 37903
GEO/T	Synchronous	23:55.5 - 23:56.5	0.0 - 180.0	0.0 - 0.85	80 - 35795	35775 - 71510
GEO/D	Drift GEO	23:00 - 25:00	0.0 - 2.0	0.0 - 0.05	32628 - 37028	34681 - 39198
GEO/ID	Inclined drift GEO	23:00 - 25:00	0.0 - 20.0	0.0 - 0.05	32628 - 37028	34681 - 39198
GEO/NS	Near-synchr.	23:00 - 25:00	0.0 - 180.0	0.0 - 0.85	80 - 37028	34681 - 73976
DSO	Deep Space	>25:00	0.0 - 180.0	0.0 - 0.50	>15325	>37028
DHEO	Deep Eccentric	>25:00	0.0 - 180.0	0.50 - 1.00	>80	>58731
CLO	Cislunar		0.0 - 180.0	0.0 - 1.00		>318200
EEO	Earth Escape					
HCO	Heliocentric					
PCO	Planetocentric					
PEO	Planetory escape trajectory					
SSE	Solar system Escape					

Table 1 : orbital categories
(http://planet4589.org/space/log/orbits.html)

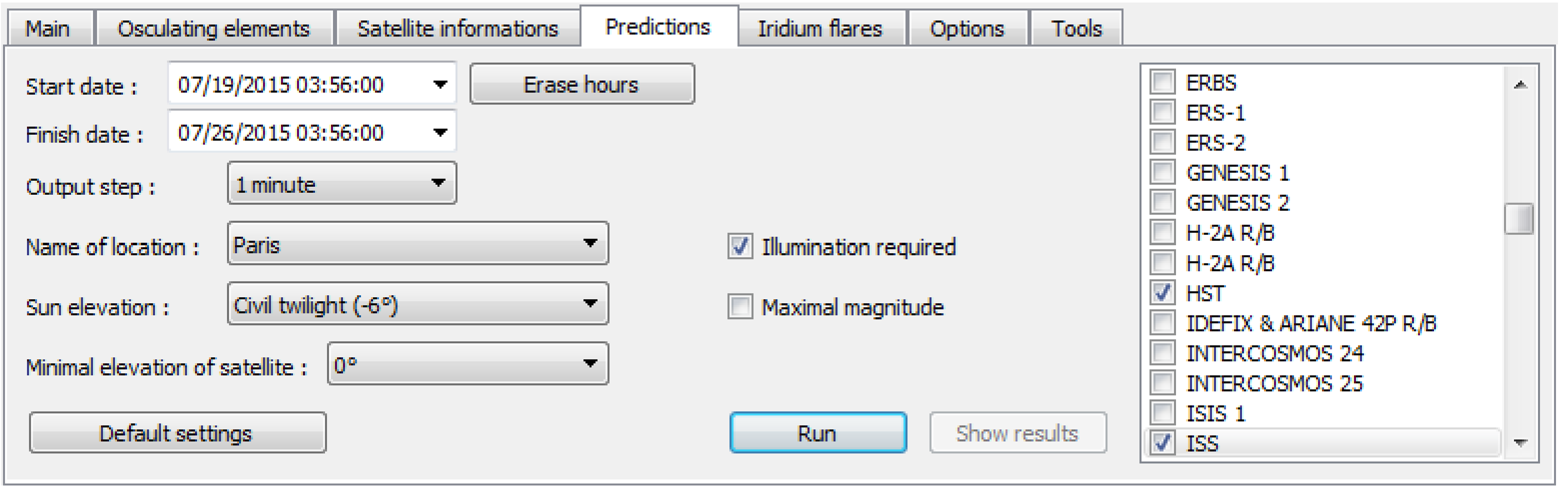
Désignation	Signification
AB	Arab satellite communications organization
AC	Asiatsat corp
ALG	Algeria
ARGN	Argentina
ASRA	Austria
AUS	Australia
AZER	Azerbaijan
BELA	Belarus
BRAZ	Brazil
CA	Canada
CHBZ	Peoples republic of China/Brazil
CHLE	Chile
CIS	Commonwealth of independent states
COL	Columbia
CZCH	Czechoslovakia
DEN	Denmark
ECU	Ecuador
EGYP	Egypt
ESA	European Space Agency
ESRO	European Space Research Organization
EST	Estonia
EUME	European organization for the exploitation of meteorological satellites
EUTE	European telecommunications satellite organization (EUTELSAT)
FGER	France/Germany
FR	France
GER	Germany
GLOB	Globalstar
GREC	Greece
HUN	Hungary
IM	International maritime satellite organization (INMARSAT)
IND	India
INDO	Indonesia
IRAN	Iran
IRID	Iridium
ISRA	Israel
ISS	International Space Station
IT	Italy
ITSO	International telecommunications satellite organization (INTELSAT)
JPN	Japan
LUXE	Luxembourg
MALA	Malaysia
MEX	Mexico
NATO	North Atlantic Treaty Organization (NATO)
NETH	Netherlands
NICO	New Ico
NIG	Nigeria
NKOR	North Korea
NOR	Norway
O3B	O3B Networks
ORB	Orbital telecommunications satellite (GLOBALSTAR)
PAKI	Pakistan
POL	Poland
POR	Portugal
PRC	Peoples republic of China

RASC	Regional african satellite communications organization
ROC	Republic of China (Taiwan)
ROM	Romania
RP	Republic of Philippines
SAFR	South Africa
SAUD	Saudi Arabia
SEAL	Sea Launch Demo
SES	Société européenne des satellites
SING	Singapore
SKOR	South Korea
SPN	Spain
STCT	Singapore/Taiwan
SWED	Sweden
SWTZ	Switzerland
THAI	Thailand
TURK	Turkey
UAE	United Arab Emirates
UK	United Kingdom
US	United States of America
USBZ	United States/Brazil
VENZ	Venezuela
VTNM	Vietnam

Table 2 : countries or organizations

VI. "Predictions" tab

The **Predictions** tab allows to make predictions of passes for one or more satellites above a given place of observation.



It is necessary to supply the initial and final dates and hours, the calculation step as well as the place of location. By default, the initial date is the current date and the initial hour is the current hour truncated to the minute; the date by default is initial date increased by 7 days. The calculation step is initially fixed at one minute.

It is possible to take into account of the magnitude of the satellite by ticking the **Maximal magnitude** box and by indicating the desired magnitude. This option will only apply to the satellites of which the standard magnitude is known.

Then, it is possible to regulate the minimal elevationwhich the satellite must have for the calculation of the predictions (for example, if the horizon of your place of observation is masked by a building, a mountain or luminous urban pollution). If you choose 'Other' in the drop-down list, you are then invited to select a positive integer value in the adjacent text field.

In the same way, you can parameterize the elevation of the Sun following the criteria below :

- Horizon (0°),
- Civil twilight (-6°), default value,
- Nautical twilight (-12°),
- Astronomical twilight (-18°),
- Indifferent, all passes will be displayed, including those of day,
- Other…, you are then invited to select an integer value ranging between -90° and +90° in the adjacent text field.

By default the list of satellites dedicated to predictions is filled by the satellites of the main list of satellites. It is possible to add or to eliminate satellites. By right clicking on the list, we can check all the satellites or none. Then just click on the **Run** button to run the search.

Once calculations are finished, an explicit message appears in the task bar and the button **Show results** appears. By clicking on this button, one can display the results obtained and then have the possibility to save them in a text file.

In the first tab of result window, the passes are written in the form of columns as shown in the following example.

Calculation for ISS and only for one day

```
PreviSat 3.4 / Astropedia (c) 2005-2015

Location                    : Paris      002°20'55" East    48°51'12" North   30 m
Timezone                    : Local time
Conditions of observations : Maximal elevation of the Sun = -6°
                              Minimal elevation of the satellite = 0°
Range unit                  : km

Age of the TLE              : 0.13 days (at 05/30/2014 08:03:00)


ISS
   Date       Hour    Sat Azimuth  Sat Elev    RA Sat    Decl Sat  Const Magn  Altitude     Range   Sun Azim    Sun Elev
2014/05/30 23:27:00  084°05'02"  00°28'42"  20h26m14s +04°14'59"  Del  +9.9*    417.4    2347.7  326°39'55"  -12°35'54"

2014/05/31 01:00:00  105°20'41"  31°55'49"  19h33m45s +14°30'24"  Aql  -1.0*    417.5     735.6  348°12'46"  -18°28'06"
2014/05/31 01:01:00  086°22'39"  19°31'45"  21h01m43s +16°54'45"  Del  +0.1*    417.9    1040.1  348°27'17"  -18°30'05"
2014/05/31 01:02:00  078°02'33"  11°23'20"  21h50m24s +16°24'00"  Peg  +1.3     418.3    1409.7  348°41'49"  -18°32'02"
2014/05/31 01:03:00  073°35'26"  05°47'59"  22h20m30s +15°07'51"  Peg  +3.1     418.6    1803.8  348°56'22"  -18°33'56"
2014/05/31 01:04:00  070°52'48"  01°39'27"  22h41m05s +13°43'20"  Peg  +6.9     418.8    2208.0  349°10'55"  -18°35'48"

2014/05/31 02:33:00  268°08'57"  14°31'46"  12h00m16s +09°41'30"  Vir  +0.7*    417.6    1242.5  010°57'29"  -18°34'11"
2014/05/31 02:34:00  274°33'19"  25°36'50"  12h14m41s +21°52'47"  Com  -0.5*    418.0     864.3  011°12'02"  -18°32'17"
2014/05/31 02:35:00  294°38'41"  46°48'58"  12h50m25s +47°27'48"  CVn  -1.7     418.3     559.1  011°26'34"  -18°30'21"
2014/05/31 02:36:00  018°13'56"  57°08'34"  20h22m37s +76°19'11"  Cep  -2.0     418.6     492.1  011°41'06"  -18°28'22"
2014/05/31 02:37:00  056°17'25"  32°15'46"  23h20m52s +45°17'49"  And  -0.9     418.9     732.3  011°55'37"  -18°26'20"
2014/05/31 02:38:00  065°34'18"  18°09'00"  23h45m10s +29°32'52"  Peg  +0.4     419.0    1092.4  012°10'07"  -18°24'16"
2014/05/31 02:39:00  069°36'03"  10°09'22"  23h57m15s +21°00'37"  Peg  +1.7     419.1    1486.8  012°24'37"  -18°22'10"
2014/05/31 02:40:00  071°54'29"  04°47'29"  00h05m45s +15°27'26"  Peg  +3.7     419.2    1893.1  012°39'06"  -18°20'01"
2014/05/31 02:41:00  073°26'55"  00°51'47"  00h12m22s +11°27'54"  Psc  +8.8     419.2    2303.7  012°53'35"  -18°17'50"

2014/05/31 04:08:00  285°00'21"  03°05'10"  12h13m54s +12°09'39"  Vir  +4.9     418.4    2053.4  033°00'47"  -12°42'00"
2014/05/31 04:09:00  287°27'45"  07°47'22"  12h19m58s +17°19'08"  Com  +2.3     418.7    1647.3  033°13'56"  -12°36'37"
2014/05/31 04:10:00  291°28'58"  14°25'19"  12h27m17s +24°53'35"  Com  +0.9     418.9    1250.8  033°27'03"  -12°31'11"
2014/05/31 04:11:00  299°31'38"  25°04'25"  12h37m47s +37°47'43"  CVn  -0.3     419.1     879.5  033°40'10"  -12°25'43"
2014/05/31 04:12:00  322°42'32"  43°47'43"  13h07m26s +64°01'42"  Dra  -1.4     419.1     586.7  033°53'15"  -12°20'14"
2014/05/31 04:13:00  033°08'11"  51°12'19"  23h40m31s +68°46'01"  Cep  -1.7     419.2     527.6  034°06'20"  -12°14'42"
2014/05/31 04:14:00  070°59'20"  30°44'58"  00h22m16s +34°41'45"  And  -0.7     419.1     759.1  034°19'23"  -12°09'09"
2014/05/31 04:15:00  082°10'11"  17°38'26"  00h33m51s +18°16'41"  Psc  +0.5     419.0    1112.0  034°32'26"  -12°03'34"
2014/05/31 04:16:00  087°10'57"  09°54'19"  00h41m36s +09°17'17"  Psc  +1.9     418.9    1502.2  034°45'27"  -11°57'57"
2014/05/31 04:17:00  090°03'42"  04°38'06"  00h48m02s +03°26'53"  Psc  +3.9     418.7    1905.8  034°58'27"  -11°52'18"
2014/05/31 04:18:00  091°58'14"  00°45'31"  00h53m30s -00°43'30"  Cet  +9.3     418.5    2314.6  035°11'26"  -11°46'37"


Elapsed time : 0.01s
```

We point out in the header of the results file the place of location, the time zone, as well as the conditions of observation (here, conditions by default).

We then display for each satellite the list of its passes (here 4 passes), separated one from another by a line jump. Each pass is made up, as we can see, from date and hour, followed by its characteristics. First of all, the azimuth and the elevation of the satellite, then the right ascension, the declination and the constellation. If the standard magnitude of the satellite is known, the visual is then calculated by means of the following formula :

$$m = m_{std} - 15.75 + 2.5 \cdot \log\left(\frac{d^2}{I}\right)$$

where *d* is the range to the observer and I the illumination. The magnitude is sometimes followed by an asterisk, meaning that the satellite is in the penumbra of the Earth. If standard magnitude is not known, the magnitude column only contains question marks (????). In the case that the satellite illumination is not required, for the instants where the satellite is in the shadow of the Earth, the magnitude column only contains dashes (----).

Next is given the altitude and the range to the satellite, then horizontal coordinates of the Sun (azimuth and elevation).

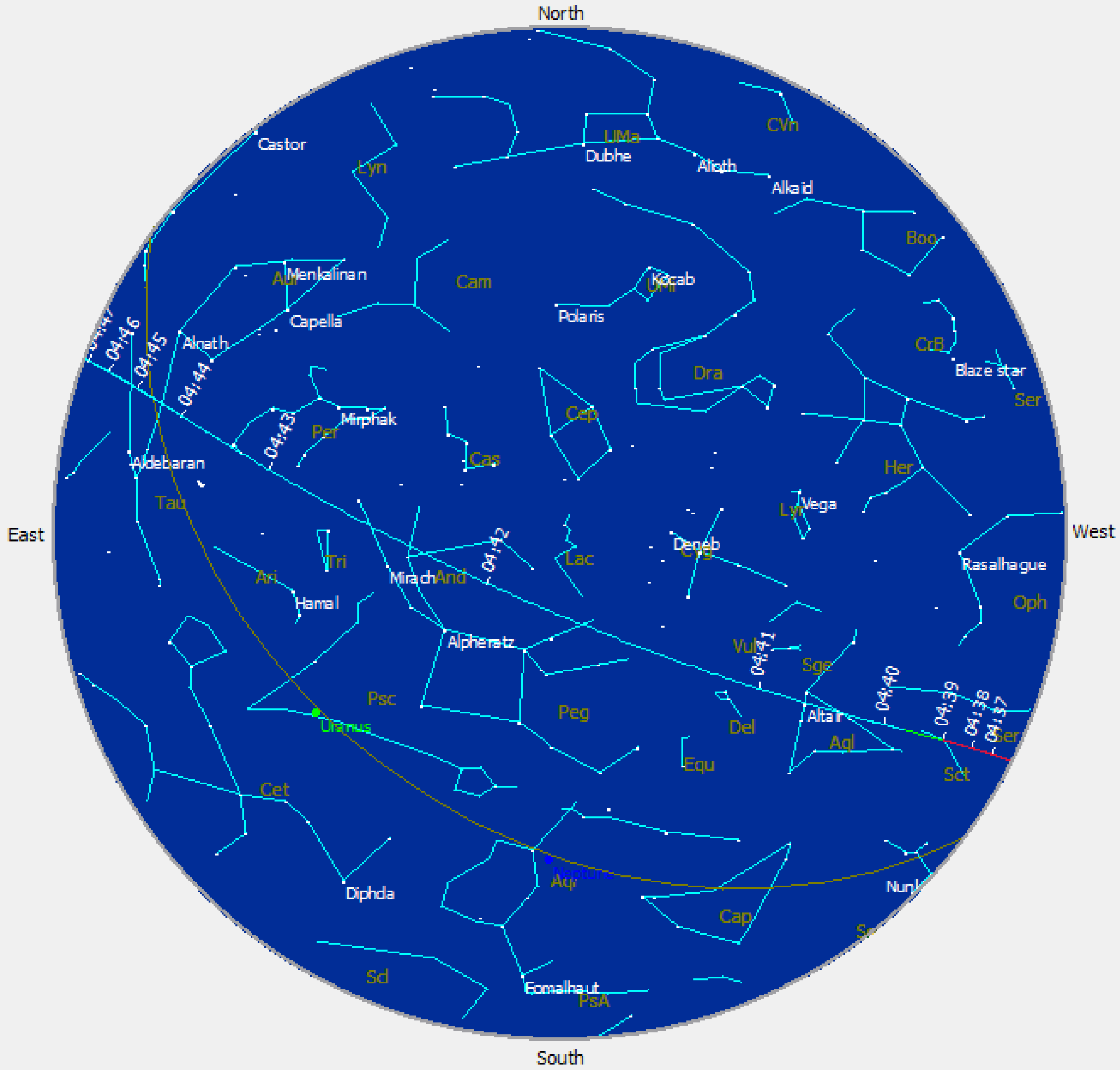
The nonvisible satellites for the search period are not mentionned in the result file.

Finally the time necessary to carry out the search is specified. This time depends in particuliar on the machine and the availability of its resources, as well as quality of search algorithm. This time is lenghtened if one chooses a long time interval and/or a short calculation step and/or a great number of satellites.

In the second tab, the table summarizes each satellite pass. By clicking on a table row, we display the corresponding passage in the sky map.

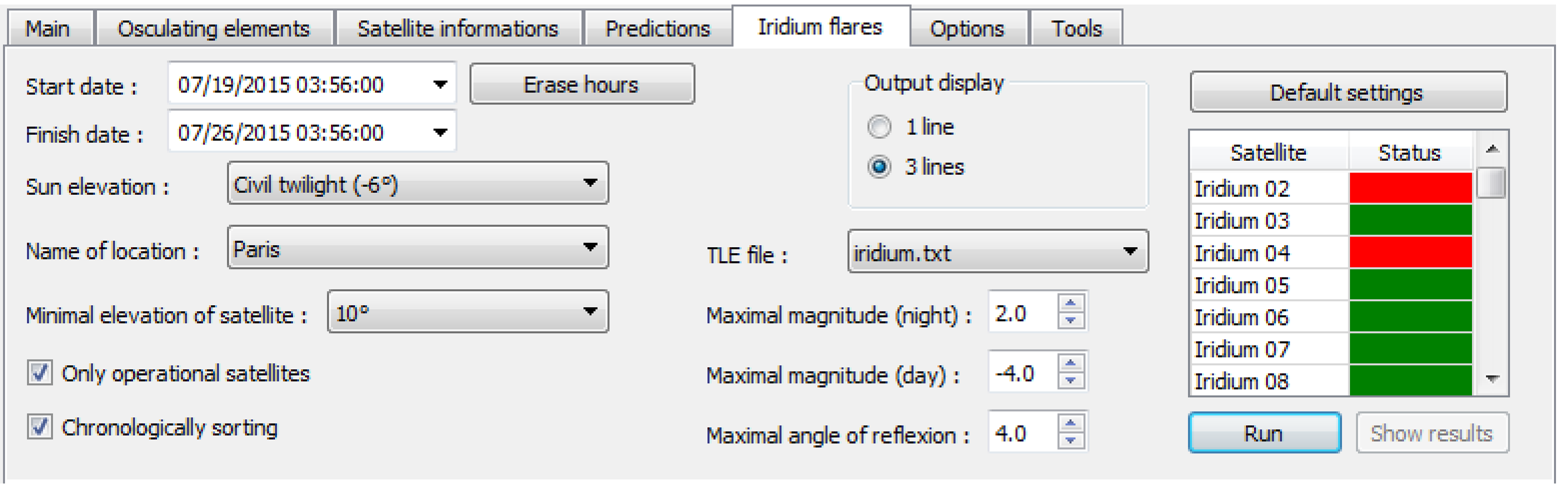
Text file | Predictions of passes

Satellite	Start date	Finish date	Max Elevation	Max Magn	Sun Elevation
HST	2015/07/21 05:12:00	2015/07/21 05:14:00	00°22'03"	+14.2	08°02'58"2
HST	2015/07/22 05:03:00	2015/07/22 05:06:00	01°07'27"	+11.8	09°15'46"2
HST	2015/07/23 04:55:00	2015/07/23 04:57:00	01°47'17"	+10.4*	10°26'54"2
HST	2015/07/24 04:47:00	2015/07/24 04:48:00	01°54'17"	+10.2	11°29'55"2
HST	2015/07/25 04:38:00	2015/07/25 04:39:00	02°12'10"	+9.7*	12°37'42"2
ISS	2015/07/19 03:58:00	2015/07/19 04:04:00	26°48'03"	-0.6	15°06'03"2
ISS	2015/07/20 03:07:00	2015/07/20 03:10:00	14°19'13"	+0.7*	18°40'01"2
ISS	2015/07/20 04:40:00	2015/07/20 04:47:00	74°16'05"	-2.3	11°18'09"2
ISS	2015/07/21 02:16:00	2015/07/21 02:17:00	03°20'26"	+4.6	20°27'08"2
ISS	2015/07/21 03:48:00	2015/07/21 03:54:00	46°14'11"	-1.7	16°14'18"2
ISS	2015/07/21 05:21:00	2015/07/21 05:29:00	56°04'26"	-1.8	06°36'47"2
ISS	2015/07/22 02:57:00	2015/07/22 03:00:00	20°20'35"	-0.0	19°29'59"2
ISS	2015/07/22 04:29:00	2015/07/22 04:37:00	65°55'16"	-2.1	12°40'05"2
ISS	2015/07/23 02:05:00	2015/07/23 02:07:00	08°55'23"	+1.9*	20°56'57"2
ISS	2015/07/23 03:38:00	2015/07/23 03:43:00	64°36'47"	-2.2	17°24'37"2
ISS	2015/07/23 05:10:00	2015/07/23 05:20:00	49°15'30"	-1.6	08°09'48"2
ISS	2015/07/24 01:13:00	2015/07/24 01:13:00	02°16'27"	+5.8*	20°28'06"2
ISS	2015/07/24 02:46:00	2015/07/24 02:50:00	39°22'39"	-1.4*	20°19'24"2
ISS	2015/07/24 04:19:00	2015/07/24 04:27:00	49°24'55"	-1.7	14°00'25"2
ISS	2015/07/25 01:54:00	2015/07/25 01:57:00	16°18'48"	+0.4*	21°22'50"2
ISS	2015/07/25 03:27:00	2015/07/25 03:33:00	64°33'41"	-2.2	18°28'13"2
ISS	2015/07/25 05:00:00	2015/07/25 05:10:00	50°12'18"	-1.7	09°41'44"2
ISS	2015/07/26 01:03:00	2015/07/26 01:03:00	02°28'26"	+5.5*	20°32'03"2
ISS	2015/07/26 02:35:00	2015/07/26 02:40:00	76°30'39"	-2.4*	21°05'12"2

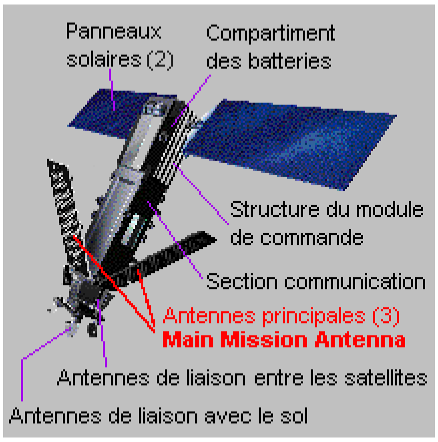


VII. "Iridium flares" tab

The **Iridium flares** tab allows to carry out of Iridium flares search, including those of day.



Initially, satellites of the Iridium constellation were satellites dedicated to telecommunications. They have 3 very reflective antennas (Main Mission Antenna, see diagram below) which are at the origin of the flares. The latter can reach magnitude -8, which is 30 to 40 times more luminous than Venus (magnitude about -4). A flare can least from a few seconds to about thirty seconds.



Flare of Iridium 37 satellite in the constellation of Queen on December 9th, 2014 at 17h34 UT in Toulouse, France (magnitude -6.8)

It is necessary to give the initial and final dates and hours. You have to specify the path of the file containing Iridium satellites (it can be a file containing only the Iridium satellites or a file containing them amongst other).

Just like for the Predictions tab, it is necessary to indicate the minimal elevation of the satellite (by default 10°) and the elevation of the Sun, which will make possible to determine the day/night transition. By default, the maximum magnitude for a night-time flare is equal to 2, while for a day-time flare, it is -4. We can also take into account the maximum angle of reflexion of the antennas (by default 4°).

Flares are calculated only for the operational satellites, that is to say for which 3-axe stabilization is assured (at least in theory). Spare satellites, placed on higher orbits, and the satellites of which attitude monitoring is doubtful are not taken into account in the calculation. To take into the spare satellites into account, de-select the box 'Only the operational satellites'. Satellites having completely lost their attitude monitoring are excluded from search.

We can choose to publish the results in the form of one line (the moment when the magnitude value passes by a minimum), or in three lines (the moment of the minimum is surrounded by the dates corresponding to the limiting conditions imposed by the preceding maximum magnitudes or the angle of reflexion). It is possible to classify the results either by satellites, or by chronological order (usual case).

In the first tab of result window, the results are displayed in the form of columns, as shown in the example below (one day calculation only) :

```
PreviSat 3.4 / Astropedia (c) 2005-2015

Location                     : Paris      002°20'43" East    48°51'39" North   0 m
Local time - UTC offset      : UTC + 01h00
Conditions of observations : Maximal elevation of the Sun = -6°
                               Minimal elevation of the satellite = 10°
Range unit                   : km

Age of the most recent TLE : 2.88 days (at 2012/03/18 16:41:00)
Age of oldest TLE          : 3.50 days


Ir     Date       Hour    Sat Azimuth Sat Elev    RA Sat    Decl Sat  Cst Ang  Mir Magn   Alt  Range   Sun Azim    Sun Elev     Max Long    Max Lat     Range    Max Magn
72  2012/03/18 20:38:52.0 104°46'58"  50°26'24"  10h32m45s +28°16'32" LMi 3.99  D  +2.0  784.4  982.1 289°04'26" -16°38'28"
72  2012/03/18 20:38:57.4 108°08'39"  49°38'10"  10h28m34s +26°10'37" Leo 3.54  D  +1.6  784.3  991.7 289°05'33" -16°39'19"  003.3625 E  48.7964 N   75.0 (E)    -7.4
72  2012/03/18 20:39:02.7 111°11'29"  48°47'25"  10h24m48s +24°11'53" Leo 3.95  D  +2.0  784.2 1002.2 289°06'37" -16°40'08"

10  2012/03/19 05:39:52.0 201°58'41"  57°08'33"  15h48m35s +17°33'20" Ser 3.62  G  +2.0  783.8  912.7 075°14'04" -13°04'42"
10  2012/03/19 05:40:03.5 198°41'43"  52°55'51"  15h52m13s +13°01'09" Ser 0.14  G  -6.9  783.6  953.3 075°16'20" -13°02'53"  002.3290 E  48.8380 N    2.8 (W)    -6.9
10  2012/03/19 05:40:14.5 196°18'22"  49°07'42"  15h55m16s +08°59'33" Ser 3.36  G  +2.0  783.5  996.9 075°18'31" -13°01'07"

60  2012/03/19 14:20:11.3 216°02'38"  21°34'03"  23h03m07s -12°35'00" Aqr 0.40  G  -4.0  781.6 1666.9 206°17'13" +37°48'54"
60  2012/03/19 14:20:13.7 216°20'49"  21°51'42"  23h02m34s -12°12'06" Aqr 0.06  G  -6.0  781.7 1654.4 206°17'55" +37°48'44"  002.3055 E  48.8330 N    4.3 (W)    -6.0
60  2012/03/19 14:20:16.0 216°39'33"  22°09'41"  23h02m01s -11°48'40" Aqr 0.40  G  -4.0  781.7 1641.8 206°18'38" +37°48'34"

Temps elapsed : 0.11s
```

The first column gives the number of the Iridium satellite responsible of the flare. Then, successively, there is the date, the hour, the coordinates of the satellite and the constellation. One then give the angle of reflection of the antenna, as well as the concerned antenna ("F" = Front, "R" = Right, "L" = Left). Next are specified the visual magnitude of the flare, the altitude and the range to the satellite, and the coordinates of the Sun. Finally, we give the terrestrial coordinates where the reflection angle reaches a minimum, the distance (at the East or at the West to the observer) and its visual magnitude.

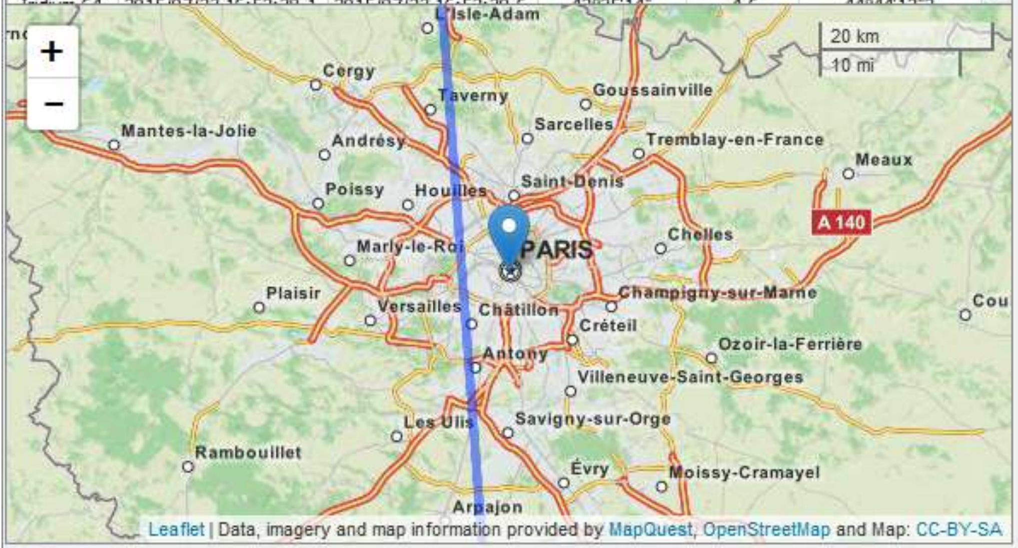
Note concerning the observation of Iridium satellites :

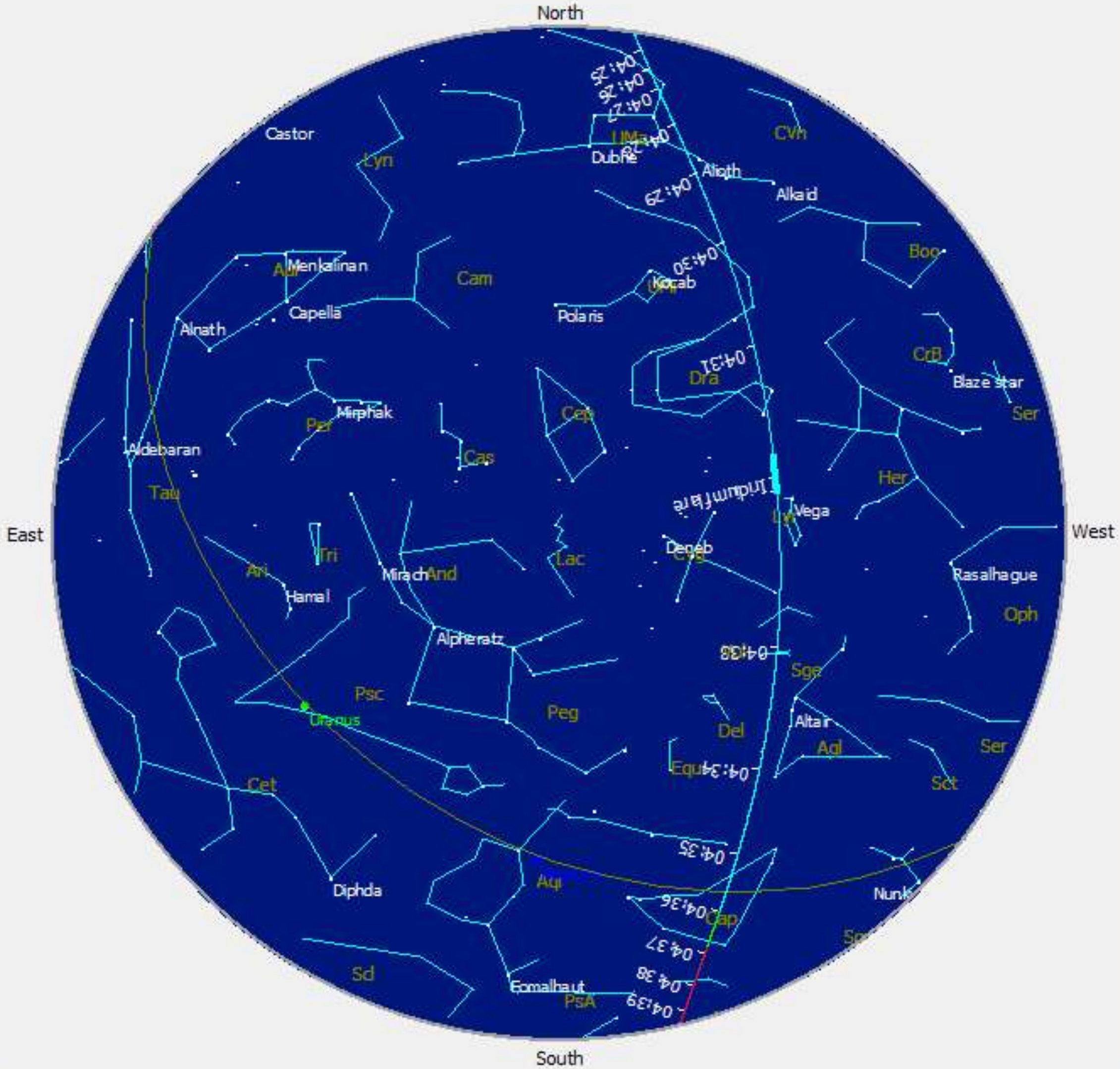
Calculation uses an internal file which provides the attitude state of the satellites, to know if the satellite is operational, spare or having lost its attitude. In general, the operational satellites produce flares such as they are envissaged by PreviSat. However, there can exist an angular offset between the true attitude of the satellite and the theorical attitude (manœuvres for example), which can result in a magnitude modification. The result provided by PreviSat is thus an estimate of the magnitude of the flare (in general, represented rather well). Thus, one should not be surprised if a flare is lower than hoped, or even did not take place.

Under the second tab, the table summarizes each Iridium flare. By clicking on a table row, we display the corresponding passage in the sky map, and a map centered on the place of observation showing where the maximum flare produces.

Text file | Iridium flares

Satellite	Start date	Finish date	Max Elevation	Max Magn	Sun Elevation
Iridium 6	2015/07/19 09:24:04.4	2015/07/19 09:24:07.0	25°02'04"	-5.7	29°48'24"0
Iridium 5	2015/07/19 23:55:09.2	2015/07/19 23:55:35.9	30°26'00"	-2.1	15°18'18"2
Iridium 6	2015/07/20 00:04:17.1	2015/07/20 00:04:34.4	25°17'27"	+1.3	16°00'20"2
Iridium 53	2015/07/20 01:21:49.4	2015/07/20 01:22:00.6	47°40'51"	+0.1	19°57'07"2
Iridium 40	2015/07/20 02:57:50.8	2015/07/20 02:58:14.2	50°15'32"	+1.0	19°04'06"2
Iridium 8	2015/07/20 23:49:17.6	2015/07/20 23:49:39.6	30°11'11"	+0.4	14°59'07"2
Iridium 77	2015/07/21 02:51:47.1	2015/07/21 02:52:08.7	50°13'54"	+1.2	19°30'14"2
Iridium 70	2015/07/21 04:31:48.6	2015/07/21 04:32:00.9	50°50'27"	-4.7	12°29'11"2
Iridium 34	2015/07/21 09:21:18.2	2015/07/21 09:21:20.3	29°02'47"	-5.5	29°04'06"0
Iridium 19	2015/07/21 23:52:21.3	2015/07/21 23:52:49.7	26°02'17"	-6.3	15°25'31"2
Iridium 34	2015/07/22 00:01:37.3	2015/07/22 00:01:47.2	21°47'50"	+1.8	16°08'34"2
Iridium 41	2015/07/22 02:55:01.2	2015/07/22 02:55:09.4	51°17'55"	+1.9	19°34'34"2
Iridium 64	2015/07/22 04:25:42.9	2015/07/22 04:25:54.0	50°06'33"	-1.9	13°15'41"2
Iridium 70	2015/07/22 16:58:45.6	2015/07/22 16:58:48.2	43°48'21"	-6.5	43°57'12"2
Iridium 97	2015/07/22 23:46:14.1	2015/07/22 23:46:38.9	26°48'14"	-0.6	15°05'06"2
Iridium 5	2015/07/22 23:55:23.2	2015/07/22 23:55:48.8	22°45'42"	-0.4	15°51'08"2
Iridium 52	2015/07/23 01:12:40.3	2015/07/23 01:12:53.9	42°35'13"	+1.0	20°15'50"2
Iridium 11	2015/07/23 06:05:44.9	2015/07/23 06:05:46.9	74°26'56"	-4.8	01°40'19"0

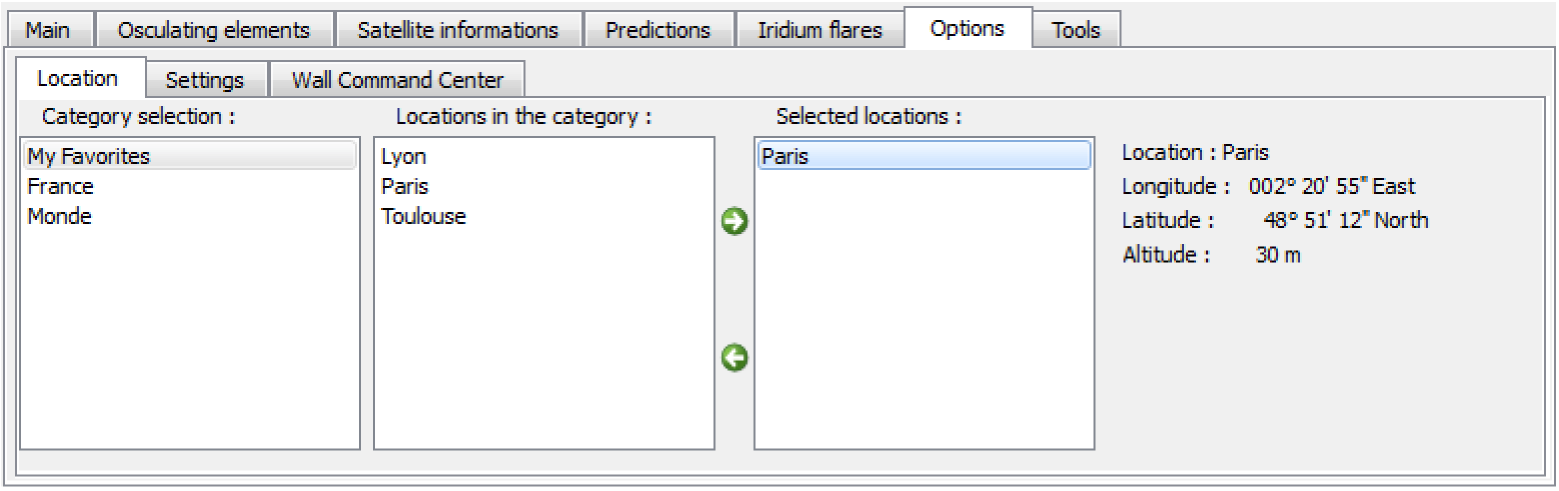




VIII. "Options" tab

The **Options** tab allows to carry tou the adjustments of PreviSat (place of observation, display).

1. "Location" tab



The first list in the **Location** tab contains the various categories of places of observation (initially France, World and My Favorites).

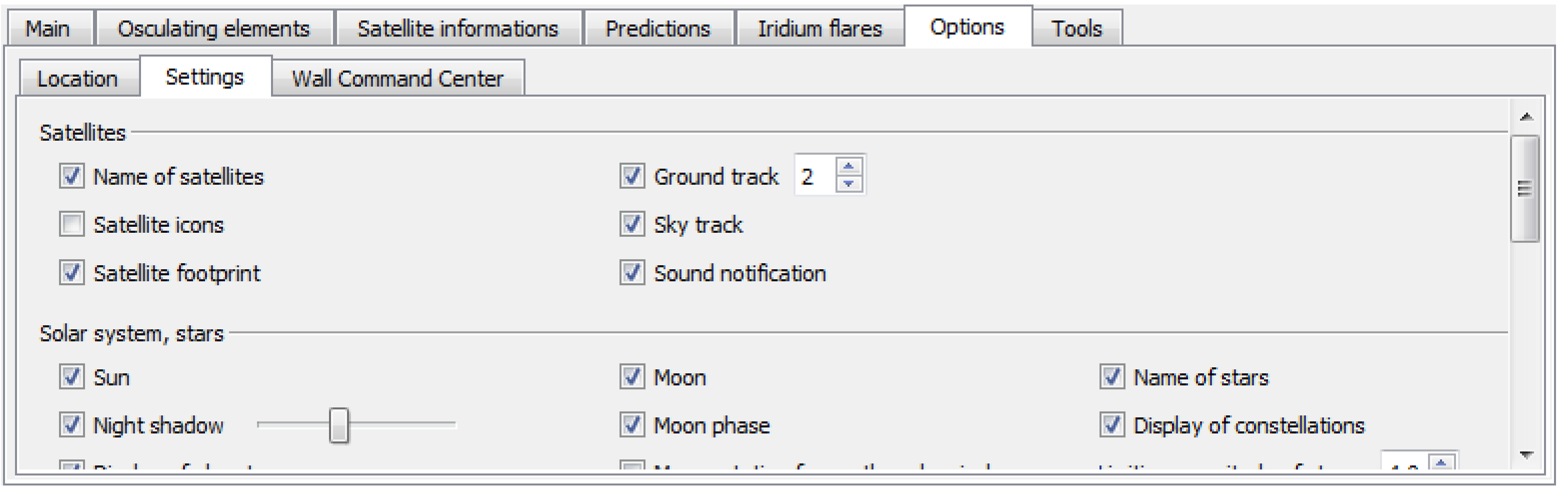
- The category **France** comprises the main towns of Metropolitan France.
- The category **World** contains the coordinates of almost 1700 cities in the world.

While clicking on an element of this first list, one reveals in the second list the names of the places of the category. When a place of observation is selected, its coordinates are displayed on the right-hand side of the tab. While clicking on the small arrows, one can select the locations for the application.

By right-clicking on an element in the **Location in the category** list, one can choose to remove it or to add it in the **My Favorites** category. For the manual addition of a place in a category, it is necessary to seize the name of the place of observation, its longitude and its latitutde. (given for example by a GPS device). The altitude can be neglected if it is not known because its value has small effect on calculations.

It is possible to create or remove a category (except the category **My Favorites**), or to download new categories by right-clicking on the list **Selection of the category**.

2. "Settings" tab



This tab contains a list of checkboxes allowing to display (or not to display) elements in the graphic interface. Some checkboxes have 3 possible states :

Name of satellites box :

- **Checked** : the names of selected satellites are displayed,
- **Partially checked** (the display of the box varies with the system requirements) : the name of default satellite is displayed,
- **Unchecked** : the display of the names of satellites is disabled.

Foot print box :

- **Checked** : the foot prints of all selected satellites display,
- **Partially checked** : the foot print of the default satellite displays,
- **Unchecked** : the display of foot prints is disabled.

Radar box:

- **Checked:** the radar only displays if a satellite is present in the sky of the place of observation,
- **Partiellement coché** : the radar displays permanently,
- **Unchecked** : the display of the radar is disabled.

Name of locations box :

- **Checked** : the names of all places of observation are displayed,
- **Partially checked** : the name of the default location displays, the other locations are represented by a white cross,
- **Unchecked** : the name of the default locationdisplays.

Display of constellations box :

- **Checked** : when the sky map is maximized, the constellation lines and names of constallation are displayed,
- **Partially checked** : constellation lines are displayed,
- **Unchecked** : the display of constellation lines and names of constellations are disabled.

A first choice list makes it possible to choose the units displayed in PreviSat. For the satellites as well as the Moon, the unit can be either kilometers, or miles (1 mile = 1.609344 km); the altitude of the place of observation and dimensions of the satellite are then expressed respectively in meters or feet (1 foot = 0.3048 m). The distance from the Sun is always given in astronomical units (1 AU = 149,597,870 km = 92,955,807 miles).

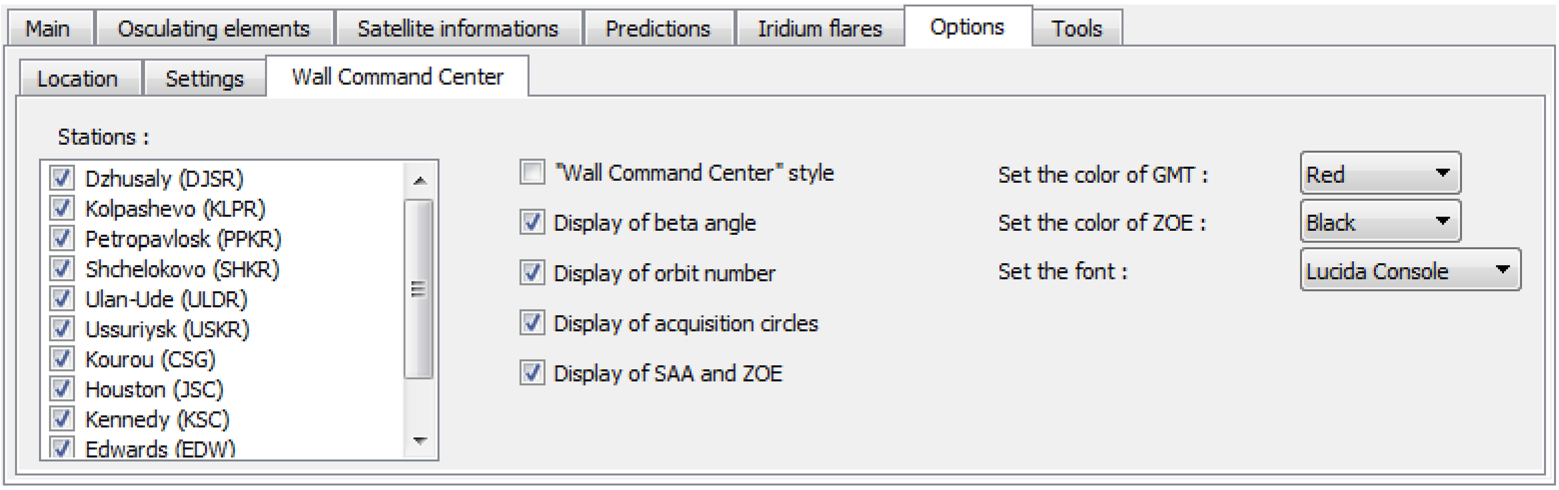
Note : After the entry of a new place of observation when the unit is the foot, the displayed altitude can slightly differ compared to the entered value, because PreviSat stores the altitude in meters and in a integer value. That does not affect any the calculations carried out by PreviSat.

A second choice list makes it possible to select the Local time - UTC offset; one can changes the value of this offset. The **Auto** checkbox, when it is checked, allows to determine automatically this offset :

- If the **Auto** checkbox is checked at the time of closing of PreviSat, the offset will be given with the system value at the next starting of Previsat.
- If not, the offset will be given by the value indicated in the field, at the next starting of PreviSat.

3. "Wall Command Center" tab

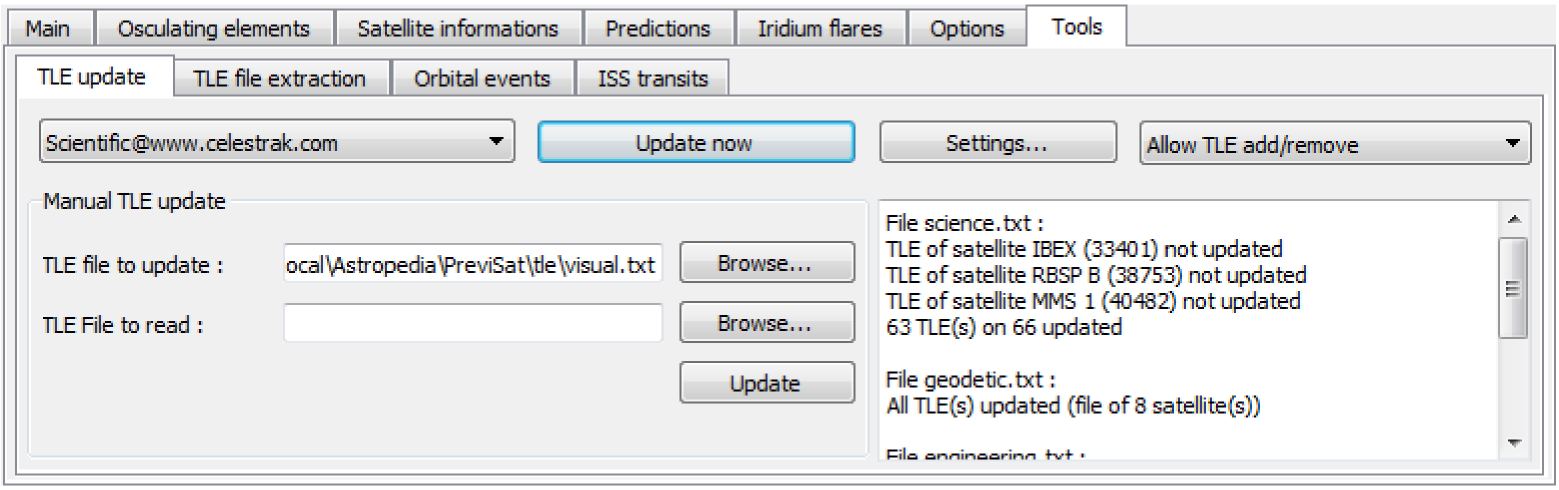
This tab allows you to manage the display options when the Wall Command Center is activated (when the "ISS Live" box is checked).



IX. "Tools" tab

The **Tools** tab makes it possible to update TLE files and to create is own TLE files from other files. Two other calculations are provided : the calculation of orbital events and the transits of ISS with the Sun and the Moon.

1. "TLE update" tab



The first tab allows updating TLE files that PreviSat uses, in order not to carry out handling manually of TLE files (decompression...). All that is carried out by this fonctionality. You may choose the category you want to update and click on the **Update now** button. PreviSat download the TLE files of the category and merges the files. When you launch the update, a report is displayed on the right-hand side of tab.

You can create or modify categories by clicking on the **Settings** button : in the window displayed, it is possible to select categories that you want to update automatically at the starting of PreviSat, and define the expiry date. If the **TLE expiry date** is checked, the TLE updating is made automatically when the TLE are older than the value indicated. If not, the TLE updating is made every starting of PreviSat.

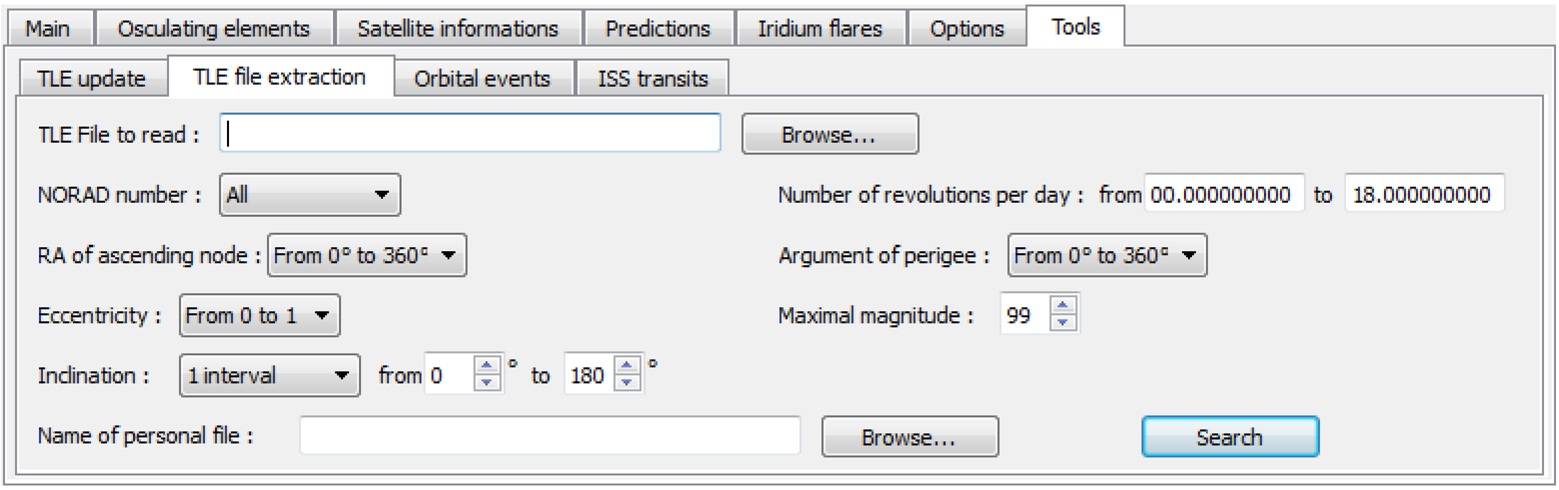
You can also update files individually by indicating the TLE file to read (containing recent TLEs) and TLE file to update. The file to read can be in the gz format.

Important : the automatic updating of files of "tle" directory of PreviSat is done from the site www.celestrak.com. Only the TLE files with the same names are downloaded from celestrak.com

2. "TLE file extraction" tab

The second tab makes it possible to create its own TLE files according to various criteria. It is necessary to indicate the name of the file to be read and the name of the personal file. One can create a file according to the following criteria (between square brackets, entries by default, wich are also the tolerated maximum values) :

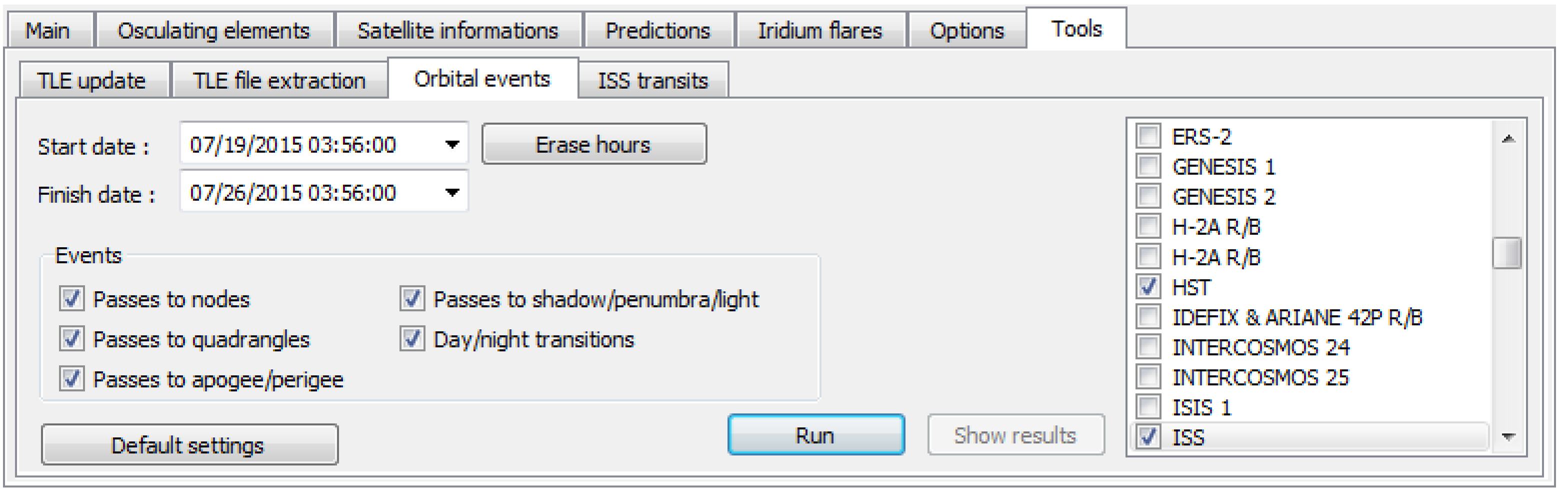
- The NORAD number [All],
- The right ascension of the ascending node [From 0 to 360°],
- The eccentricity [From 0 to 1] (value 1 is excluded),
- The number of revolutions per day [From 0 to 18],
- The inclination [From 0 to 180°] (it is possible to define 2 intervals),
- The argument of perigee [From 0 to 360°],
- And the maximum magnitude [99] (The value 99 indicates that the magnitude is not a selection criteria).



For example, one wants to build a file containing the most luminous those of which the standard magnitude is known. One can retain the following criteria :

- NORAD number : All
- Right ascension of the ascending node : From 0 to 360°
- Eccentricity : From 0 to 0.001 (slightly eccentric; one could tolerate satellites of which the orbit is more eccentric and to take from 0 to 0.2)
- Number of revolutions per day : From 14 to 18 (to keepthe satellites at low altitude, potentially most luminous)
- Inclination : From 35 to 145° (so as to be visible in temperate zones of the northern hemisphere of the Earth)
- Argument of perigee : From 0 to 360°
- Maximal magnitude : 4 (all the satellites where the minimal magnitude is lower than 4 will be kept)

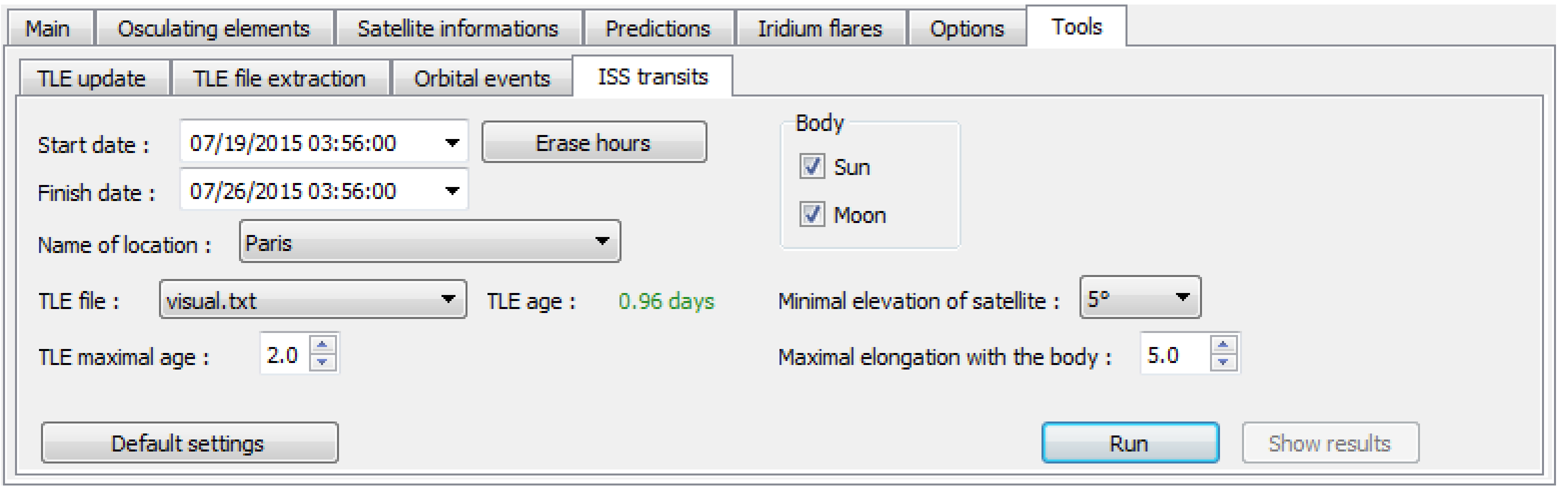
3. "Orbital events" tab



The third tab allows to determine the orbital events of the selected satellites. We can choose the events :

- The passes of the satellite to ascending and descending nodes (equatorial crosses),
- The passes to quadrangles (at position = 90° and 270°), that is to say the passes to the maximal latitudes,
- The passes to shadow/penumbra/light,
- The passes to apogee/perigee,
- And the day/night transitions, that is to say the passes of the satellite over the day/night limit.

4. "ISS Transits" tab

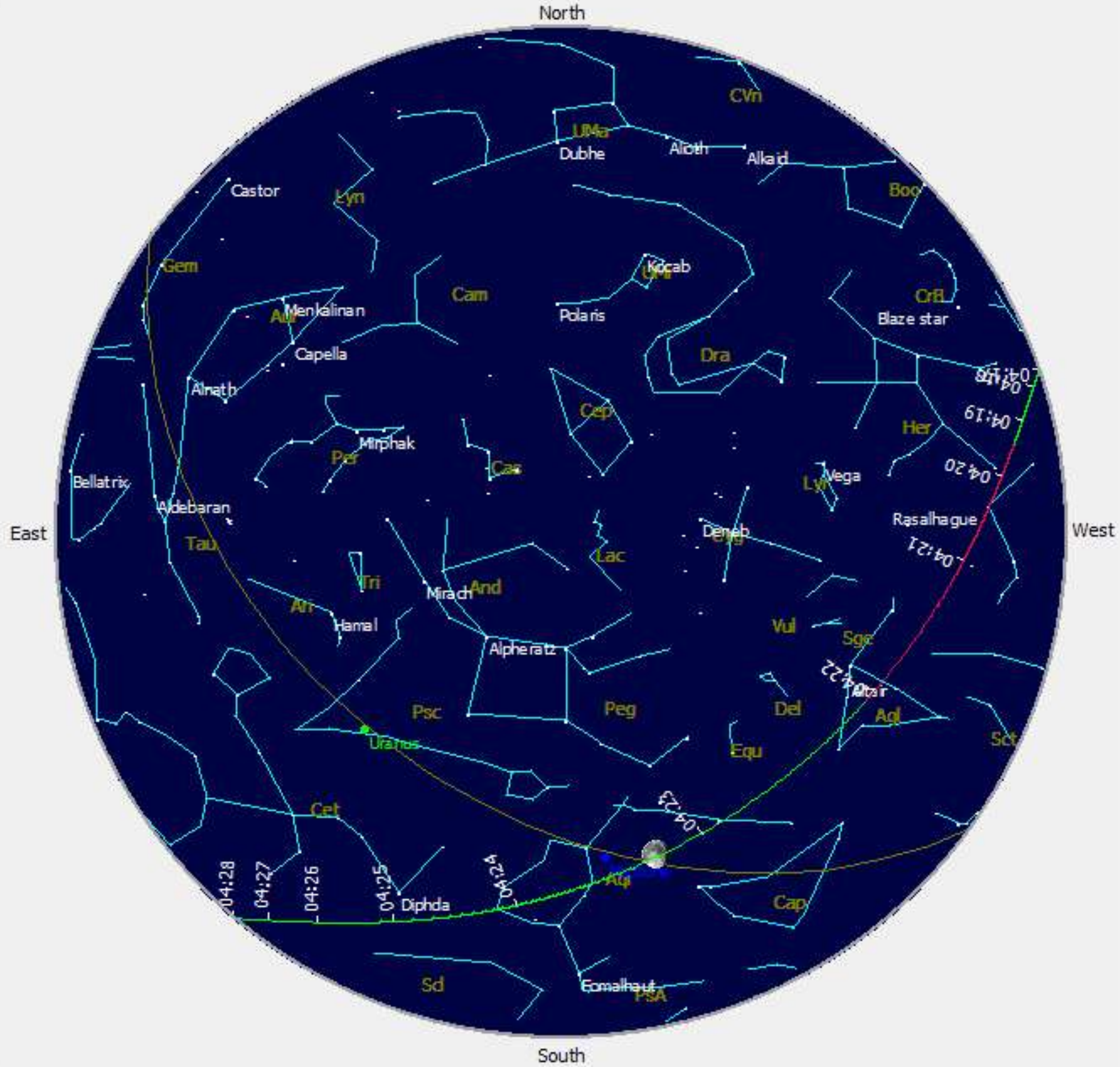


The fourth tab allows calculating the conjunctions and the transits of the ISS with the Sun and/or the Moon. It is necessary to give the initial and final dates and hours, the place of location and the TLE file containing the orbital elements of ISS. You have to specify which bodies you want to calculate the transits (Sun and/or Moon), the minimal elevation of satellite and the maximal elongation between ISS and the body.

The file containing the results shows in its header the conditions of obsevations. he results are provided under the form of columns which contain the date and hour, and then the coordinates of ISS (azimuth, elevation, right ascension, declination and constellation). We then give the angular separation between ISS and the center of the considered body, the phenomenon type (C = Conjunction; T = Transit), the body (S = Sun; M = Moon), and also the illumination of ISS (Ill = Illuminated; Pen = Penumbra; Ecl = Eclipsed). We finally give the altitude and the range of the satellite, and the topocentric coordinates of the Sun.

Text file | ISS transits

Satellite	Start date	Finish date	Angle	Type	Body	Sun Elevation
ISS	2015/07/30 22:08:07.2	2015/07/30 22:08:29.1	4.06	C	M	05°45'04"
ISS	2015/08/01 05:15:47.9	2015/08/01 05:16:11.4	1.13	C	M	09°47'19"
ISS	2015/08/02 04:23:02.7	2015/08/02 04:23:20.8	0.53	C	M	15°46'52"
ISS	2015/08/14 19:53:10.4	2015/08/14 19:54:35.4	1.50	C	M	11°00'38"
ISS	2015/08/14 19:53:54.8	2015/08/14 19:55:00.0	1.94	C	S	10°55'16"
ISS	2015/08/15 19:00:53.0	2015/08/15 19:01:39.0	1.88	C	S	19°21'01"



Annexes

Annex 1 : List of constellations

Designation	Latin	Englush	French
And	Andromeda	Princess	Andromède
Ant	Antlia	Air Pump	Machine Pneumatique
Aps	Apus	Bird of Paradise	Oiseau de Paradis
Aql	Aquila	Eagle	Aigle
Aqr	Aquarius	Water Bearer	Verseau
Ara	Ara	Altar	Autel
Ari	Aries	Ram	Bélier
Aur	Auriga	Charioteer	Cocher
Boo	Bootes	Herdsman	Bouvier
Cae	Caelum	Chisel/Burin	Burin
Cam	Camelopardalis	Giraffe	Girafe
Cap	Capricornus	Sea Goat	Capricorne
Car	Carina	Keel	Carène
Cas	Cassiopeia	Queen	Cassiopée
Cen	Centaurus	Centaur	Centaure
Cep	Cepheus	King	Céphée
Cet	Cetus	Sea Monster/Whale	Baleine
Cha	Chamaeleon	Chameleon	Caméléon
Cir	Circinus	Compass/Dividers	Compas
CMa	Canis Major	Breat Dog	Grand chien
CMi	Canis Minor	Small Dog	Petit Chien
Cnc	Cancer	Crab	Cancer
Col	Columba	Dove	Colombe
Com	Coma Berenices	Berenice's Hair	Chevelure de Bérénice
CrA	Corona Australis	Southern Crown	Couronne Australe
CrB	Corona Borealis	Northern Crown	Couronne Boréale
Crt	Crater	Cup	Coupe
Cru	Crux	Southern Cross	Croix du Sud
Crv	Corvus	Crow/Raven	Corbeau
CVn	Canes Venatici	Hunting Dogs	Chiens de Chasse
Cyg	Cygnus	Swan	Cygne
Del	Delphinus	Dolphin	Dauphin
Dor	Dorado	Dorado	Dorade
Dra	Draco	Dragon	Dragon
Equ	Equuleus	Colt	Petit Cheval
Eri	Eridanus	River Eridanus	Éridan
For	Fornax	Furnace	Fourneau
Gem	Gemini	Twins	Gémeaux
Gru	Grus	Crane	Grue
Her	Hercules	Hercules/Strong Man	Hercule
Hor	Horlogium	Pendulum Clock	Horloge
Hya	Hydra	Water Serpent	Hydre Femelle
Hyi	Hydrus	Small Water Snake	Hydre Mâle
Ind	Indus	Indian	Indien
Lac	Lacerta	Lizard	Lézard
Leo	Leo	Lion	Lion
Lep	Lepus	Hare	Lièvre

Lib	Libra	Scales	Balance
LMi	Leo Minor	Small Lion	Petit Lion
Lup	Lupus	Wolf	Loup
Lyn	Lynx	Lynx	Lynx
Lyr	Lyra	Lyre/Harp	Lyre
Men	Mensa	Table Mountain	Table
Mic	Microscopium	Microscope	Microscope
Mon	Monoceros	Unicorn	Licorne
Mus	Musca	Fly	Mouche
Nor	Norma	Carpenter Square	Équerre
Oct	Octans	Octant	Octant
Oph	Ophiuchus	Serpent Bearer	Ophiucus
Ori	Orion	Hunter	Orion
Pav	Pavo	Peacock	Paon
Peg	Pegasus	Winged Horse	Pégase
Per	Perseus	Perseus/Hero	Persée
Phe	Phoenix	Phoenix	Phénix
Pic	Pictor	Painter's Easel	Peintre
PsA	Piscis Austrinus	Southern Fish	Poisson Austral
Psc	Pisces	Fishes	Poissons
Pup	Puppis	Poop	Poupe
Pyx	Pyxis Nauticus	Ship's Compass	Boussole
Ret	Reticulum	Net	Réticule
Scl	Sculptor	Sculptor	Sculpteur
Sco	Scorpius	Scorpion	Scorpion
Sct	Scutum	Shield	Écu de Sobieski
Ser	Serpens	Serpent	Serpent
Sex	Sextans	Sextant	Sextant
Sge	Sagitta	Arrow	Flèche
Sgr	Sagittarius	Archer	Sagittaire
Tau	Taurus	Bull	Taureau
Tel	Telescopium	Telescope	Télescope
TrA	Triangulum Australe	Southern Triangle	Triangle Austral
Tri	Triangulum	Triangle	Triangle
Tuc	Tucana	Toucan	Toucan
UMa	Ursa Major	Great Bear	Grande Ourse
UMi	Ursa Minor	Little Bear	Petite Ourse
Vel	Vela	Sail	Voiles
Vir	Virgo	Maiden	Vierge
Vol	Volans	Flying Fish	Poisson Volant
Vul	Vulpecula	Fox	Petit Renard

Annex 2 : Version history

Version 3.4 (revision 5) :

October 2014 - September 2015

- Added the weather window for the observer location and for NASA bases.
- Removing the obsolete video stream of ISS Live.
- Changing the display of ISS Live for MacOS X platform.
- Added the magnitude of the Moon.
- Small improvements in source code.
- Corrections for display.
- Corrections in checking software update.
- Corrections in TLE manager.

Version 3.3 (revision 1) :

November 2013 - September 2014

- Added the ISS Live.
- Added the Wall Command Center visualization.
- Added the 12-clock/24-clock option.
- Added the map for predictions results.
- New calculation of satellite eclipses (with atmospheric refraction).
- Correction of local time offset in the calculations of predictions.
- Correction in TLE updating.

Version 3.2 (revision 1) :

July - November 2013

- Modification for checking updates.
- Added more information on the satellites.
- Conservation of the list of satellites for each file of the TLE directory.
- Display of TLE age in ISS Transit tab.
- Display of Iridium satellites status.
- Calculation of Iridium magnitude in the main window.
- Minor correction in the prediction of passes.
- Standization of source code for Windows/Linux/MacOS X platforms.

Version 3.1 (revision 3) :

October 2012 - July 2013

- Correction for low resolution screens.
- Modification of TLE files management in the user interface.
- Night vision mode.
- Calculation of adapted orbital parameters.
- Online setup.
- Bug fix in checking TLE validity

Version 3.0 (revision 5) :

July 2011 - October 2012

- C++/Qt development.
- New implementations for predictions of passes, Iridium flares, orbital events and ISS transits.
- Calculation of coordinates of the maximum for Iridium flares and ISS transits.
- Modifications in the graphic user interface : adding planets, display of the SAA (South Atlantic Anomaly).

Version 2.3 (revision 4) :

January - October 2011 :

- Many internal modifications.
- Add the sky map (with the constellations and the name of main stars).
- Maximised display of world map or sky map.
- Add the simulation mode.
- Downloading of new locations and world maps, management of TLE downloading.
- Management of satellite names for TLE with 2 lines.

Version 2.2 (revision 2) :

October 2009 - November 2010 :

- Sizeable main window.
- Display of the Moon.
- Management of several locations on the world map.
- Calculation of ISS transits with the Sun and the Moon.
- New display options.

Version 2.1 (revision 8) :

April - October 2009 :

- SGP4 model with corrections from D. Vallado (use of oriented object programmation).
- Multi-satellite management (calculation algorithms, display).
- New algorithm for Iridium flares, TLE updating and the creation of personal TLE files.
- Several modifications concerning display.
- Many improvements of source code (manual mode, Iridium flares, ...).
- Calculation of orbital events.
- Screen shot of the main window at JPEG or BMP format.
- Automatic download of orbital elements (TLE).

Version 2.0 (revision 8) :

January 2008 - April 2009 :

- New graphical interface with VB2005, simplification of its use.
- Rewriting of all the procedures : adaptation to the language VB2005, translation in C language of the procedures containing many mathematical operations.
- New management of locations.
- Significant optimization of predictions and Iridium flares.
- New display options.
- Display of the zone of shade.
- Gradual variation of the radar coloured background according to the elevation of the Sun.
- New calculation of the satellite foot print and the zone of shade.

Version 1.2 (revision 11) :

June - December 2006 :

- Modification of the layout of elements in the graphic interface.
- Add the radar.
- Creation of TLE personal files and their update.

Version 1.1 (revision 15) :

December 2005 - June 2006 :

- Predictions of Iridium flares (personal algorithm concerning the magnitude).
- Add the sound notification and the satellite foot print.
- Add the Sun, the terminator and the list of satellites in the main window.
- Display of the future ground track of the satellite.
- Add the satellite Informations.
- Decompression of TLE files with gz format.

Version 1.0 (revision 114) :

September 2005 - February 2006 :

- Developing the module calculating position and velocity with orbital models SGP4/SDP4.
- Numeric display of the position (vectors position and velocity, then in the various reference points).
- Calculation of the predictions of a satellite.
- Add the world map.
- Add shortcut buttons on the graphic interface.
- Add the Real-time mode, the status bar and of the calculation of osculating elements.
- Prediction of several satellites.
- Add the manual mode.
- Save results in a text file.
- Choice among several steps in manual mode.
- Optimization of the calculation of the predictions.

Annex 3 : Technical features

1. Development

Software	Version	Comments
PreviSat	3.4.5.15	27,000 lines of source code
Qt Creator	3.4.2	IDE
Qt Library	4.8.7	GUI Library
CppCheck	1.69	Checking and analyzing of source code
Inno Setup Compiler	5.5.6 (a)	Installation setup for Windows
Tortoise Hg	3.5	Version control software
UPX	3.91	Executable file compression software
zlib	1.2.8	File compression/decompression library

2. Used Models and constants

Component	Reference	Author	Comments
Propagation model	SGP4, Spacetrack report n°3, Models for propagation of NORAD Element Sets	Hoots, Roehrich, Vallado	Revision of 2006 (corrections brought by Vallado)
Sun position **Moon position** **Planets positions** **Sidereal time of Greenwich**	Astronomical Algorithms 2nd edition	Meeus	Simplified model. pp163-164 Simplified model. pp337-342 Simplified model. pp209-216 From the formula p88
Osculating elements	Fundamental of Astrodynamics and Application 2nd edition	Vallado	
Atmospheric extinction	Magnitude corrections for atmospheric extinction, 1992	Green	
Catalog of main stars	Bright Star Catalog 5, 1991	Hoffleit	

Constant	Symbol	Value	Origin
Gravitational geocentric constant	GM	398 600.8 $km^3.s^{-2}$	WGS-72
Second zonal harmonic	J2	0.001 082 6158	WGS-72
Third zonal harmonic	J3	-0.000 002 538 81	WGS-72
Fourth zonal harmonic	J4	-0.000 001 655 97	WGS-72
Flatness of Earth globe	f	1/298.26	WGS-72
Terrestrial equatorial radius	Re	6378.135 km	WGS-72
Astronomical unit	AU	149 597 870 km	UAI 1976
Solar equatorial radius	$R_\odot$	696 000 km	
Lunar equatorial radius	$R_☾$	1738 km	
Magnitude of solar disc center		-26.98	

Annex 4 : Thanks

I would like to thank :

- T.S. Kelso for the information he communicated to me and numerous information available on his site www.celestrak.com,
- David Vallado for the publication of corrected model SGP4 (2006) and the calculation methods present in his **Fundamental of Astrodynamics and Applications** (consult the site www.celestrak.com to buy it),
- Jean Meeus, where the **Astronomical Algorithms** supplied the essential astronomical calculations (calculation of the julian day, Sun's position, sidereal time...),
- Michel Casabonne, whose support and contributions helped to bring new features and significant improvements to PreviSat,
- and people who helped me in the development of PreviSat, for their advice and their software tests (thanks Claudia, Yannis, Rémi, JB, Benoît, Maurice, Jean-Louis !).

I also address thanks to all the people who expressed to me their appreciations of the software.

1. Translations

English : Mr O'Donoghe

2. Graphics (icons, splashscreen)

Claudia Martinez

Annex 5 : Contact - License

This software is under the GNU GPL license version 3. The numerical results can be distributed freely, as well as predictions (passes of the satellites and Iridium flares) have no restrictions. The lastest version of the software can be downloaded free at the site astropedia.free.fr. Any non-authorized commercial distribution is strictly prohibited.

For any information, suggestion or in the event of a problem, send an e-mail to the author of the software at the following address : astropedia@free.fr.